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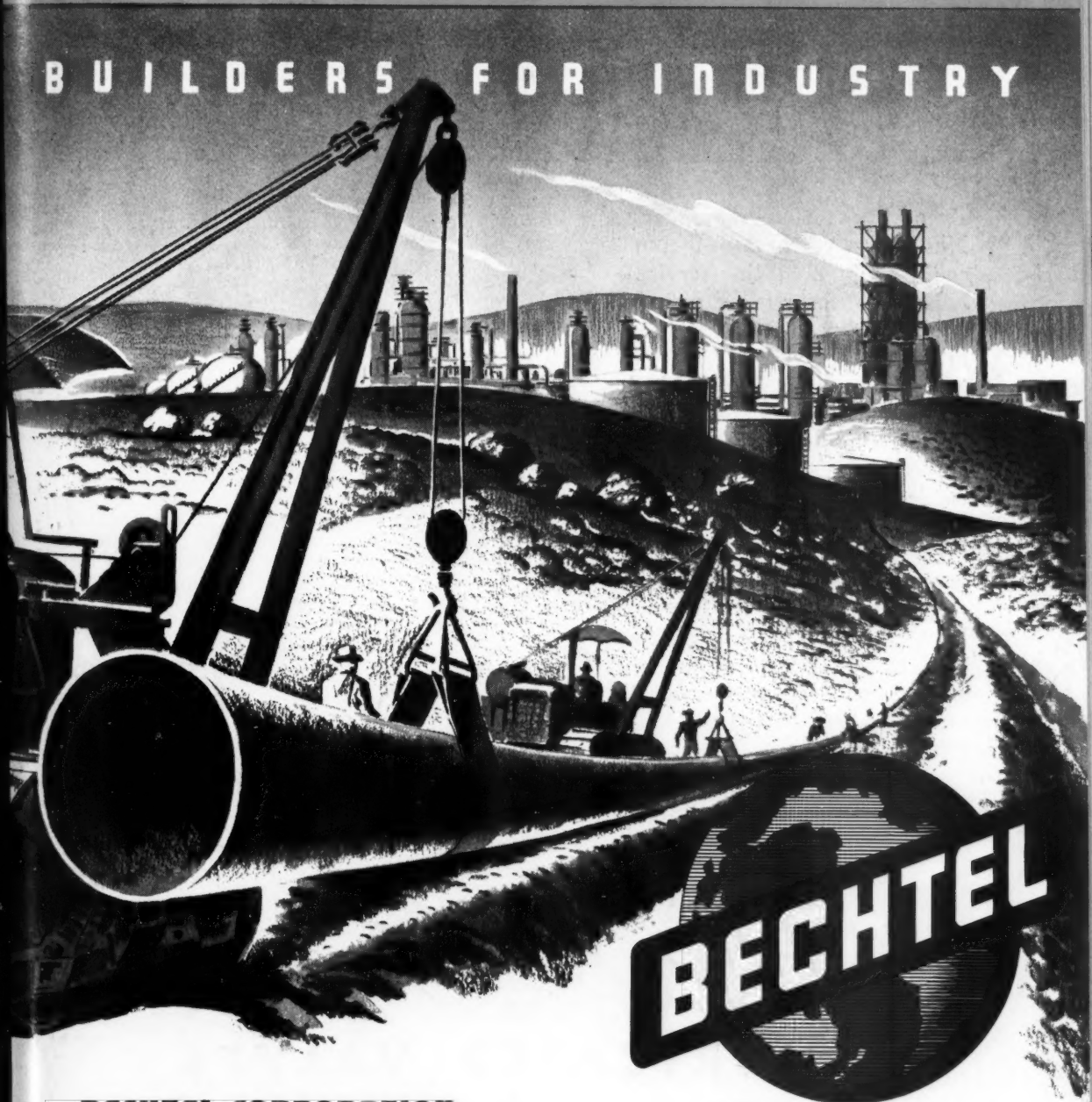

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Fig. 22845—3000 Lb. W.O.G.
2", 3" and 4"—(A.S.A. 1500-Lb. Flanges)
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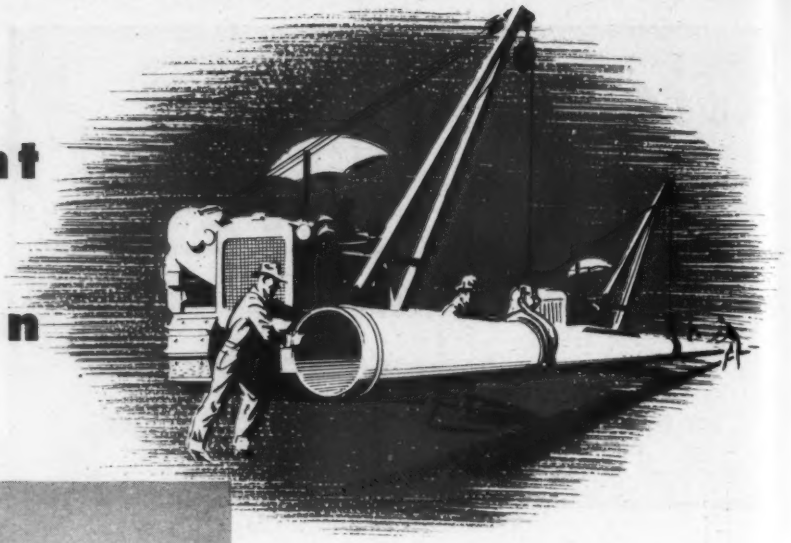
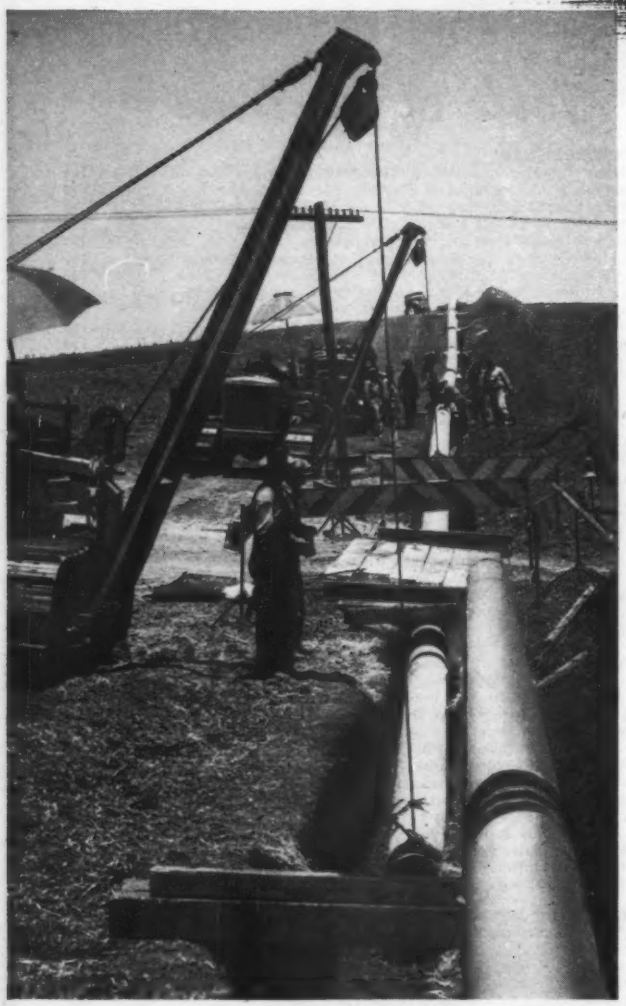
Permanent Pipe Protection





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An Amazing Record

FROM its beginnings the petroleum and natural-gas industries have had the services of aggressive and competent pipeliners who have overcome numerous problems in the transportation of liquid and gaseous hydrocarbons. But no period of the past has approached the current growth in facilities and the technical accomplishments in all phases of pipe-line activities.

The reports in this issue reveal that pipe lines under construction or definitely announced total approximately 24,000 miles, a mileage sufficient to span this country east and west more than six times. Outside this country, projects, mostly of "big inch" capacity, exceed 5,000 miles. This is an amazing record, the significance of which extends far beyond the industrial confines of the operators concerned.

In this country expansion in crude-oil pipe lines at present centers in new capacity to relieve the postwar shortages of the Middle West. Large increases in demand created this problem, which management is solving regardless of the costs involved. In the offing are plans for major pipe lines to take care of the enlarged output of Rocky Mountain fields connecting to outside areas, and West Coast states will shortly be compelled to supplement California crude-oil output with pipe-line supplies from the Southwest.

With product pipe lines under construction or authorized aggregating more than 5,000 miles, the petroleum industry is moving toward a goal in which it will be largely independent of other means of transporting refinery products. Mounting rail and water-transportation costs are giving impetus to this program of connecting petroleum-consuming centers to one or more product pipe lines.

What is happening in natural-gas transmission is apparent from the latest quarterly consumption data. Total sales of natural gas increased 17.6 per cent the second quarter of this year over the same period in 1946 with commercial sales up 33.8 per cent, residential sales 25.1 per cent, and industrial sales 17 per cent. Natural gas now has nearly 10,000,000 customers.

Future trends are indicated in the fact that nearly 11,000 miles of additional natural-gas lines are being laid, authorized, or proposed. Most of these new lines are of large diameter with capacities 2 to 15 times those of two decades ago.

Developments in construction and operating methods are as outstanding as the growth in pipe lines. The several engineering discussions of this issue are proof of that situation, for which technologists are responsible.

The end is not in sight. Unhampered by unwarranted government restrictions, the pipe-line division, as an integral part of oil and natural-gas operations, will continue to expand its services, a direct contribution to the reestablishment of a sound national economy.

Current Jersey Standard Expansion Involves $400,000,000 Outlay

STANDARD OIL CO. (N. J.) estimates expansion programs being undertaken throughout the world by the company and its affiliates involve an expenditure of at least $400,000,000 with some $121,000,000 being spent in 1947 by domestic affiliates on producing activities alone.

The Jersey company's expansion one of the greatest programs of its kind in the company's history, shows the scope of the efforts of the petroleum industry to meet current record-breaking world-wide demand for its products.

The $400,000,000 expenditure by the Jersey organization accounts for a sizable share of the entire industry's outlay. Last June, a survey by the American Petroleum Institute revealed that the domestic petroleum industry is spending some $4,000,000,000 for new and improved facilities in 1947 and 1948, a sum representing more than 22 per cent of the total investment in the nation's oil industry.

Highlights of the expansion program of Jersey Standard were given in a survey by the Lamp, company publication. This showed that Humble Oil & Refining Co. this year is drilling nearly 700 wells, and Carter Oil Co. is drilling about 200 this year. Heavy expenditures for United States exploration also are being made.

The domestic affiliates also are making capital expenditures of nearly $60,000,000 this year for modernization and construction of refinery facilities. Next year they plan to spend about $75,000,000, according to the Lamp's survey.

Standard Oil Co. of New Jersey, the principal manufacturing and marketing affiliate, plans to spend more than $50,000,000 to modernize and expand refineries and other manufacturing facilities. At Linden, N. J., a 2-year program of expansion in the Bayway refinery will include the world's largest catalytic cracking plant and new pipe stills. At the Baton Rouge, La., refinery the expansion program is being carried out with no slackening in the operating rate of existing equipment. New pipe stills are planned, and two catalytic cracking units are undergoing modernization to increase their capacity 8,000 bbl. a day each. Other modernization and expansion projects also are under way at the company's refineries at Baltimore, Md., and Charleston, S. C.

The Humble company is spending $5,000,000 expanding its Baytown, Tex., refinery, and another $2,000,000 to enlarge pipe-line outlets from West Texas to Gulf ports. *(Jersey Standard's foreign expansion is described in a story on page 159).*

Carter Resumes Work at Billings Despite Soaring Costs

ALTHOUGH the cost will be more than two and one-half times the amount originally contemplated, Carter Oil Co. this week prepared for immediate resumption of work on its new 20,000-bbl. daily refinery at Billings, Mont.

Earlier in August, the company halted construction on the new plant for a reappraisal of the project in view of rapidly rising labor and material costs. In announcing work will be continued, O. C. Schorp, Carter president, said, "It is still impossible to predict the exact cost of the new refinery . . . the scope of the project was enlarged to some extent but the higher expenditure may be attributed principally to the increased costs of labor and materials."

When construction was stopped, R. B. Curran, Carter vice president and Northwest division manager, said the original cost estimated in 1946 when the project was first announced, was $10,000,000. In March of this year, rising costs had boosted the figure to $16,500,000, and more recent studies at that time indicated costs will be much greater than the latter figure.

Carter also announced that the company will proceed with a marketing-development program by resuming construction and remodeling of service stations and bulk plants, and that it will acquire the physical assets of Fargo Oil Co., which operates 15 service stations in the Denver area. These stations will become Carter outlets September 15.

Schorp's statement last week gave a "go-ahead" signal to contractors and came after Carter engineers had devoted weeks of study to the increased construction costs. Major contractor on the project is Fluor Corp., Ltd.

"The demand for petroleum products in the area served by Carter Oil Co. is mounting rapidly, and the new refinery is urgently needed to give the consuming public the quantity and quality of products it needs," Schorp said, "so we have decided to complete the plant despite the increased construction cost."

The refinery, on a 344-acre site east of Billings, will include a crude unit, a catalytic cracking unit, laboratory, shops and warehouse, tank-car loading facilities, and process-equipment buildings. This refinery will be the largest in the Rocky Mountain area.

When operating at capacity, the plant will produce about 350,000 gal. of high-octane gasoline daily, as well as fuel oil, asphalts, diesel fuels, kerosine, tractor fuels, and heating oils.

Carter now operates four refineries in Montana and Wyoming. The present Billings refinery, with capacity of 9,500 bbl. daily, will continue in operation until completion of the new plant.

Active Rotary Rigs Reach New High

THE number of rotary rigs operating throughout the United States and western Canada reached another all-time high as of September 1 with figures showing a total of 1,969—60 above the total at the beginning of August.

The high in rotary rigs operating was the latest of a string of records being set in oil-industry operations under the stimulus of an unprecedented demand for crude and products.

Figures as of September 1, released by the Interstate Oil Compact Commission, showed a marked gain in the number of rigs active in the Gulf Coast area, West Texas, and the Pacific Coast region. Of the eight areas included in the breakdown, only one, Kansas, showed a drop in the number of rigs operating.

The total of 1,969 active rigs was listed for the end of the month, but it was reported an even greater number, 1,985, were operating as of August 25.

The following table gives comparative figures:

ROTARY RIGS ACTIVE

	Aug. 1	Sept. 1
Pacific Coast	129	144
Oklahoma	247	251
Kansas	125	108
Rocky Mt., inc. Western Canada	185	185
N. La., E. Tex., and Ark.	158	164
W. Tex., N. Tex., and New Mex.	455	472
Gulf Coast	496	527
Illinois, inc. Ill., Ind., Ky., Mich. and Eastern areas	114	113
Total	1,909	1,969

Government Files Proposed Decree In "Tidelands" Case

WASHINGTON.—Effect of the proposed final decree offered last week by the Department of Justice to carry out the Supreme Court decision of June 23 in the submerged oil land case is to leave later questions to adjudication.

On September 13, the Justice Department filed with the Supreme Court a decree which it was proposed the court issue in this case declaring that the United States "is now, and has been at all times pertinent hereto, possessed of paramount rights of proprietorship in, full dominion and power over, the land, minerals, and other things," in the submerged land off the California coast.

It was noted that the Justice Department did not go so far as to assert federal ownership, but only proprietorship, in the "tideland" oil. Thus it followed the limitations of the June 23 Supreme Court decision.

Thus, as far as it goes, the proposed decree merely aims at confirming and carrying out the court decision.

However, in the final paragraph it is proposed that "jurisdiction is reserved by this court to enter such further orders and to issue such writs as may from time to time be deemed advisable or necessary to give full force and effect to this decree."

Principal Unsettled Question

Effect of this, it was explained in an informed official quarter, is that the court must later either decide upon other questions not yet settled, or these may be the subject of litigation if the court does not settle them of its own volition.

The principal unsettled question is the defining of what constitute inland waters, such as what are the boundaries of inland waters in San Pedro Bay.

It is said that the proposed decree would make no substantive change in the situation as it existed before it was announced. With the announcement of the Secretary of the Interior several days earlier that the Interior Department would not take advantage of the court decision (because it did not have to apply the leasing act) without a special law by Congress, the Department of the Interior is not going ahead to assert its jurisdiction at present. That a law for this purpose will be sought from Congress is promised by the officials concerned.

Until such a law is approved, if it is approved, all requests for federal leases or licenses are out the window.

In connection with the whole subject of submerged oil lands, it is forecast that the federal Government most definitely does have an interest in the action of the Texas School Land Board in proposing to lease more than 2,000,000 acres of submerged lands in the Gulf of Mexico.

After the Texas announcement, the Department of Justice was reported not interested in the action, because under the act making Texas a member of the federal Union, Texas reserved to her own jurisdiction, all public lands.

Despite the difference in the basis for Texas' claim to the offshore oil lands, the federal Government feels, it was explained, that it should assert a nation-wide claim to jurisdiction over such resources as a matter of national defense.

On the other hand, there is no word as to whether the Justice Department will institute court action against Texas until the Administration has tested in Congress next year its request to be empowered to control leasing of oil lands in the "tidelands."

Cities Service to Build East Chicago Laboratory

PLANS for the construction of a new technical-service laboratory located on the site of its East Chicago, Ind., refinery, have been announced by Cities Service Oil Co.

Functions of the laboratory will be primarily sales service, including service testing and other forms of product evaluation. New-product development for specific application is also contemplated. In addition, the laboratory will serve as the central testing point for product quality control during manufacture and will develop test standards for refinery laboratory use.

Special investigations will be conducted relating to refinery operation such as corrosion control, waste disposal, chemical treatment, and general processing improvements. A completely equipped analytical laboratory will handle chemical analyses of all kinds, with special emphasis on petroleum and its products. Routine and standardized tests peculiar to the petroleum industry can be made in the testing section, including engine tests and other simulated service life evaluation.

Crude-oil evaluation will be conducted in specially built equipment designed to furnish necessary information relative to processing crude. An extensive library will be maintained.

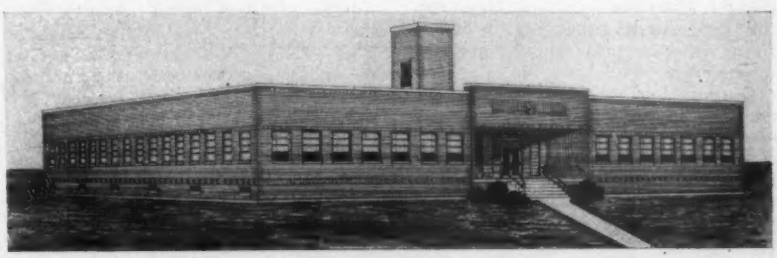
Personnel at Okmulgee, Okla., under the direction of T. E. DeVilliers, will be transferred to the new laboratory upon its completion. In East Chicago, Cities Service operates a refinery with 30,000 bbl. daily crude capacity.

Prewar Applicants to Get Preference for U. S. Leases

WASHINGTON.—Nearly 1,000 applicants for oil and gas leases on public lands upon which development work was halted during the war years will be given an opportunity to resume operations under new regulations of the Bureau of Land Management, Secretary of the Interior J. A. Krug said last week.

The regulations provide that those whose requests for a government lease were rejected when the land was drafted for military use will have a right to reinstate their applications when termination of the "war service" of the land is officially announced.

Under the new regulations, announcement of the termination of the "war service" of withdrawn lands will be made by publication in the Federal Register. Holders of previously rejected applications will be accorded a preference period of 153 days from the date of publication in which to seek reinstatement. A preference period of 60 days will be accorded applicants where the land areas were set aside by a special-use permit.



Sketch of the proposed testing laboratory of Cities Service Oil Co. in East Chicago, Ind. The one-story, U-shaped building will include approximately 10,000 sq. ft. of floor space

Oil Industry Needs Both Large and Small Companies, Dunlop Says

A VIGOROUS refutation of claims that the petroleum industry is becoming more and more "monopolistic" was made this week by Robert G. Dunlop, president of Sun Oil Co., in a talk before the National Petroleum Association's forty-fifth annual meeting in Atlantic City.

In his first major industry speech since he succeeded J. Howard Pew as Sun president last March, Dunlop cited numerous statistics and other data showing that the smaller companies in the industry are as strong as ever.

"Anyone familiar with the industry can cite instances of phenomenal gains, both in crude production and refinery output, as well as net worth, made by comparatively smaller companies in the 1940-46 period," he said. "They are the companies which will be listed by some Senate committee among the so-called majors of tomorrow.

"Of course it is true that during the last 7 years a number of small refineries were shut down and dismantled. Some small refining companies went out of business or were absorbed by larger enterprises. But that is part of a trend that has been going on for 20 years or so.

Increasing Technological Development

"It does not result from any malevolent or sinister action on the part of other companies but rather from the increasing technological development of refining in response to demands for higher-quality petroleum products.

"All that this indicates is that petroleum refining, to be efficient today, must be done on a fair-sized scale. Since the oil industry is a mass-production business requiring large capital investment, especially in its refining division, this should come as no surprise."

Dunlop told the N.P.A. that his decision to accept the invitation to speak came "when my eye fell upon a news story from Washington quoting an eminent senator as asserting that the oil industry offered an illustration of how industrial concentration was threatening independent business all over the country. This statement is so preposterous—so devoid of substance and so far from the facts—that it demands to be challenged and refuted. . . .

"Most familiar of all these warmed-over charges are contentions which imply that 20 of the larger companies in the industry are engaged in some kind of a diabolical plot to destroy or restrict opportunity for the remaining 34,000 or so 'independent' enterprises that make up our industry.

"Characterization of all companies but the 20 largest integrated units as 'independents' is a distortion when we all know that each of these 20 is as fully independent in every true sense of the word as any of those outside of the Temporary National Economic Committee list."

Dunlop declared that among things which point to independence of oil companies is the vigorous competition, independence of thought and action, independence from money-lenders in financing through ploughing back earnings into the business, and in management.

Size Alone No Evil

Dunlop said we hear a lot today that size—and size alone—is evil. He declared "such is not the case," and asserts the framers of our antitrust laws directed their attention to the abuse of size and power and that such abuse included an intent and an act to restrain trade and eliminate competition. The courts, however, he said, have gone far beyond that objective in recent decisions indicating that size alone is, in effect, monopoly, and accordingly penalties should be imposed.

"Despite the fact that the industry by its nature requires big, strong companies, there is a place and abundant opportunity for the smaller companies if they are efficient and keep in step with the times," he said. "Not only is there opportunity for the small units, but they render great services to the industry and the public.

"The efficient small operator sets the competitive pace of the industry. The world is his oyster and he can be choosey in selecting the manner in which he goes about getting the share he wants."

Dunlop spoke about the greater freedom of smaller companies in getting in and out of operations; in selecting and specializing; and in maintaining sound human relationships throughout the organization. Small companies develop well-rounded executive talent, he added.

"Eventually large corporate organizations become unwieldly, limited by individual capacity to deal with the multiplicity of the divisional and departmental details. . . . There is no better place to undertake a new venture than in the very shadow of a large corporation's undertakings.

"Thus I would say that oil's door of opportunity remains wide open for those who are willing to work and compete to attain a place in this industry. As Mr. Howard Pew has said on another occasion, 'None of us has any divine right to a place and a share in this industry. He who serves the public best in quality and price is entitled to the business.'"

Railroads' Contention

In another talk at the meeting, Harry S. Elkins, traffic attorney for the N.P.A., said in an analysis of the railroads' case for another rate increase that the railroads contend that the 1948 passenger miles will be 60 per cent less than in 1944 and that freight movements will be the principal source of revenue, from which the railroads say they must have more returns to remain solvent.

Some, but not all, petroleum and petroleum products fall into the group on which is sought percentage increases rather than a flat maximum figure per unit of weight, he said.

Three petitions have been filed by the railroads with the Interstate Commerce Commission since July 3, 1947, for freight rate increases. Shippers are expected to strongly assert their right to be heard, Elkins said. Their arguments will be that they "cannot pay the increased rates and that much tonnage will cease to move, or if it does, will move by other types of carriers." Their argument will also be that the rising spiral of prices must be stopped at some point, and soon, he added.

The commission has relaxed its procedure to speed the hearings by accepting written statements in lieu of verbal testimony and will make every effort to shorten the time required to hear the cases, Elkins continued.

History and organization of the lubrication committee of the American Petroleum Institute were outlined in a talk at the N.P.A. meeting by D. P. Clark, Pittsburgh, assistant general manager, lubricating sales, Gulf Oil Corp., and secretary of the committee.

"Lubricants do not serve their real purpose until they are set to work in the equipment of the ultimate consumer," Clark said. "The objective of the lubrication committee is to correlate and disburse the technical data on lubricants and devices for their application so that the consumer may receive better service, increase production, lower maintenance and lubrication costs."

(A further report on the N.P.A. meeting will appear in The Oil and Gas Journal's issue of September 27).

this week

INVESTIGATIONS—United States grand jury investigating gasoline prices and petroleum marketing practices in the District of Columbia area dismissed. . . . Government attorneys indicate inquiry will be resumed by another jury later. . . . ¶Tulsa hearing set for September 28 by subcommittee of Senate small-business committee canceled due to conflict with I.P.A.A. meeting. . . . B. L. Majewski, Deep Rock marketing official, denounces Wherry hearings as a "waste of taxpayers' money" and declares evidence fails to bear out Senator Wherry's charge that independents are being squeezed out of business. . . . ¶House expenditures subcommittee in Washington opens investigation into action of federal Bureau of Supply in approving upward revisions in prices paid under oil contracts after OPA's demise. . . . Testimony given that at least one company faced bankruptcy if held to originally contracted prices. . . .

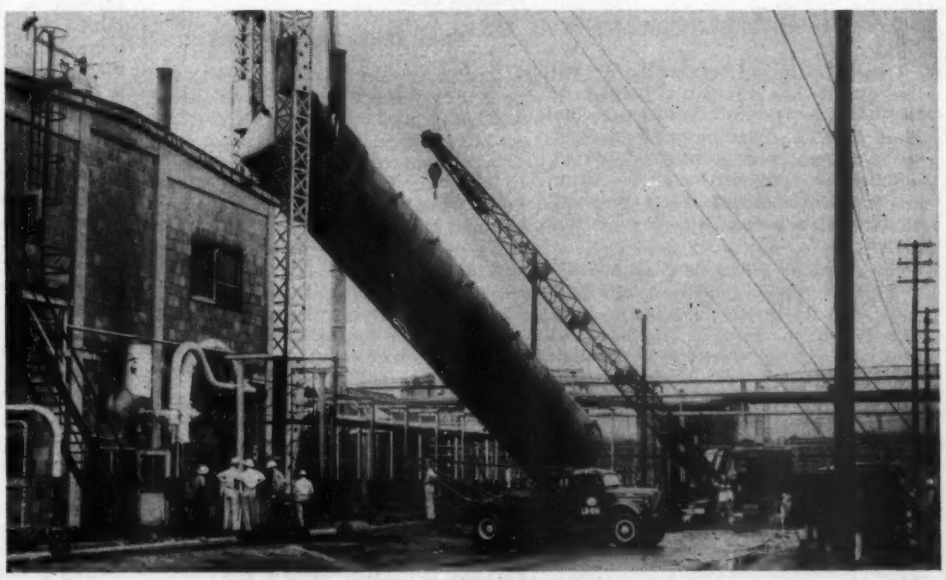
INTERNATIONAL—Question of approval of proposed Russian concession in northern Iran gathers increasing political significance. . . . Immediate approval by Iranian Parliament held unlikely. . . . U. S. ambassador backs Iran's freedom to make its own decision. . . . ¶Plans thus far formulated for joint Anglo-Iranian, Jersey, Socony-Vacuum line from Persian Gulf to Mediterranean indicate Tartus, in Latakia, will be terminal. . . . ¶Special Texas fire fighters arrive at Poza Rica to attempt to extinguish fire in one of the oldest and biggest producers in Mexico's major field. . . . ¶Pemex confirms contract with J. Edgar Jones, Baton Rouge oil operator, to drill 100 wells at an estimated $20,000,000. . . .

TIDELANDS—Texas School Land Board votes to proceed with November 4 sale of leases in 2,000,000 acres Gulf Coast offshore lands. . . . Board estimates state will lose $2,000,000 because of cloud on title caused by "tidelands" decision. . . . ¶U. S. Department of Justice submits to Supreme Court a proposed decree to carry out its June 23 decision. . . . Decree would leave such questions as definition of inland waters boundary for further litigations. . . .

RECORDS—Number of rotary drilling rigs operating climbs to new high as of September 1. . . . ¶United States crude-oil production sets new all-time record week ended September 15 with The Oil and Gas Journal tabulation showing 5,226,085 bbl. daily average. . . .

MARKETS—Texaco rolls back prices in Standard of Jersey marketing territory to meet competition resulting from Jersey's continued policy of holding prices unless they result in additional supplies of products. . . . ¶Max W. Ball, OGD director, says Government has no authority to reimpose gasoline rationing and that such action is not contemplated. . . . ¶Public Roads Administration estimates total vehicle registrations in 1947 will reach record high of 37,164,000. . . .

EXPLORATION—New light-oil field discovered in Wyoming's Big Horn Basin. General Petroleum discovery flows 445 bbl. . . . ¶Tests continue on important Phillips Petroleum Ellenburger strike, 2 miles southeast of Andector field, West Texas. . . . ¶Discovery well of Duncan Northeast pool in southern Oklahoma looks better on production tests. . . . ¶New field opened 2 1/2 miles southeast of Kelsey field, Southwest Texas. . . . ¶Union Producing test opens new gas field for Harris County, Texas Gulf Coast. . . . ¶New field indicated for South Louisiana by Stanolind's Vermilion Parish wildcat. . . .



Scenes such as this illustrate the great expansion currently under way in the petroleum industry and its refining branch. This treater tower is being placed on its foundation at the No. 1 phenol plant at the Baton Rouge, La., refinery of Standard Oil Co. of New Jersey, Louisiana Division. It is part of a lubricating-oil expansion program at the refinery. The photograph shows the tower, 12 ft. in diameter, 58 ft. long, and weighing 80 tons, being raised between two 100-ft. guy derricks by refinery personnel. The job took less than 3 hours, though several days were required to set up the equipment

DR. LOUIS SCHMERLING DR. V. N. IPATIEFF DR. WARREN K. LEWIS

Prominent scientists at the meeting of the Petroleum Chemistry Division, American Chemical Society, this week in New York, included: Dr. Louis Schmerling, research chemist with Universal Oil Products Co., who was presented with the first Ipatieff Award, to be given at 3-year intervals for most outstanding achievements in high pressure and catalysis; Dr. V. N. Ipatieff, Russian-American scientist and authority on high-pressure reactions and catalysis in chemistry, who, with Mrs. Ipatieff, contributed the fund to the American Chemical Society, from which the Ipatieff Award is made; and Dr. Warren K. Lewis, well-known technologist and research leader at Massachusetts Institute of Technology, who received the Priestley Medal, highest award of the society for outstanding achievements in chemistry

New Methods Improving Synthetic Fuel Prospects, A.C.S. Told

by Arch L. Foster

NEW YORK.—Synthetic fuels and new developments in their manufacture, the outlook for these fuels in the future; research on jet and gas-turbine fuels, the requirements for such fuels and the isolation of fuel and other hydrocarbons were the main topics of discussion at the 112th national meeting of the American Chemical Society here September 15-19.

Concentration of research effort in these fields has intensified greatly in the postwar period, and from the large number of laboratories engaged in studying these problems, a great number of advance reports were made at this meeting, the largest yet held by this largest of all scientific societies.

High-quality synthetic gasoline will be manufactured at low cost and on a large scale in America within 10 years, said Dr. A. R. Powell, Koppers Co. associate research director, in discussing American progress in adapting the Fischer-Tropsch synthesis to large-scale commercial production. He pointed out that the present demand for motor and other fuels has far outstripped our prewar needs, and that this demand promises to continue increasing indefinitely. This synthesis of liquid fuels may be one of the major technical developments of the next decade, Powell said as he discussed the subject before the joint meeting of the divisions of Gas and Fuel, and Petroleum Chemistry in what proved to be probably the most outstanding symposium of the meeting, occupying the attention of the two large divisions for 2 days of two sessions each.

Most Important Problem

Most important in the problems attacked by the researchers in this field is that of producing low-cost synthesis gas in large volume. This gas contains hydrogen and carbon monoxide in ratio of 1:1 (theoretically, when made from methane and oxygen) and from it the entire gamut of aliphatic and many other hydrocarbons are synthesized by the Fischer-Tropsch reaction. The enormity of the problem of supplying even our present gasoline needs by this process is indicated by Powell's statement that this job will require 30 trillion cubic feet of synthesis gas annually. Natural gas is the cheapest and most plentiful raw material at present, Powell said, but the process demands the lowest possible investment cost and the practice of the greatest operating economies to enable the process to compete and meet price demands. The coal and petroleum-natural gas industries here find a common meeting ground for research and development.

The Girdler process for the manufacture of hydrogen from natural-gas hydrocarbons, with some small modification, can be used to make synthesis gas in which the ratio of carbon and hydrogen is correct for this intermediate product, R. E. Reitmeier, K. Atwood, H. A. Bennett, Jr., and H. M. Baugh, of Girdler Corp., told the symposium. This process for hydrogen manufacture removes the carbon dioxide formed and converts the monoxide to the dioxide for removal. If the first-produced dioxide is taken out, the resulting mixture is suitable for synthesis of hydrocarbons, the authors said. To increase the carbon monoxide content to the desired ratio of 2 hydrogen to 1 CO, more CO_2 may be added to the reacting mixture of hydrocarbon and steam. By controlling temperatures, pressures, and flow rates, these authors are able to produce synthesis-gas mixtures varying in hydrogen-monoxide ratios from 0.5 to 2.0, without deposition of carbon on the catalyst when treating methane. When using propane as charge stock the proper conditions for avoiding carbon deposition were worked out in pilot-plant operation.

A review of several American and German processes for making synthesis gas from coal and other solid materials was given by L. L. Newman, U. S. Bureau of Mines. He stressed the use of oxygen directly in the formation of monoxide and hydrogen and discussed at length the variables involved.

Coal for Making Synthesis Gas

Production of synthesis gas from powdered coal directly, without the intermediate coke-formation step is recommended by P. W. Edeburn, L. D. Schmidt, J. P. McGee, F. Bonar, A. E. Sands, and H. W. Wainwright of the Bureau of Mines. The result as obtained by a newly developed technique yields a cheaper synthesis gas than by any other known method, it is believed. The synthesis-gas cost is half the total cost of making liquid hydrocarbons by this process, these authors said. Very small amounts of impurities such as coal tar, coal dust, ammonia, and gum-forming substances may prevent the Fischer-Tropsch reaction, it was reported in another discussion by three of these authors. Special analytical methods are required to determine or discover these impurities, others which may be present being sulfur and sulfur organics, hydrogen cyanide, naphthalene, and other aromatics, also iron carbonyl.

M. I. T. Technique with Coal

Another outstanding technique was reported at the meeting by Warren K. Lewis and colleagues at Massachusetts Institute of Technology, speaking before the general assem-

bly of the society. Lewis was awarded the Priestley Medal, highest honor conferred by the society, for "distinguished services in chemistry." According to the M.I.T. report, all grades of coal may be gasified by suspending the finely powdered solid in a stream of hot air and steam, following the well-known fluid principle used in catalytic cracking.

Development of the Swedish oil-shale industry has reached a point where 185,000 bbl. of motor fuel is made per year, Dr. Gustav Egloff, Universal Oil Products Co. and 1947 chairman of the A.C.B. Petroleum Division, reported. Kerosine to the amount of 22,000 bbl. is made, and of other fuel oils some 320,000 bbl. are produced, Egloff said, with an annual production of 750,000 bbl., total, by 1950 expected.

Aluminum chloride is an active catalyst for many hydrocarbon reactions, Dr. Louis Schmerling, Universal Oil Products Co., said, and is sometimes too active.

Majewski Again Assails Wherry Investigation

IN a talk September 16 before the Petroleum Division of the National Association of Credit Men in Chicago, B. L. Majewski, vice president, Deep Rock Oil Corp., repeated his demand that the current investigation of the Senate small-business committee into petroleum supply be conducted on a nonpolitical and "above-board" basis.

Majewski last week in a 5,000-word letter to Sen. Kenneth S. Wherry (Rep., Neb.), chairman of the subcommittee, termed the conduct of the investigation "political witch-hunting," and said nothing in the record bore out Wherry's charges independents are being eliminated from the industry. Majewski told the credit men that he expected denials to his charges.

Further in his talk, the Deep Rock official, speaking primarily for the industry, said the small percentage of refiners charging jobbers and wholesale consumers extortionate prices for their marginal requirements of products "are nothing more than black-market operators with whom retribution will eventually catch up. In the meantime, unfortunately, they are bringing down on the great rank and file of the industry unfair criticism . . ."

Unless Midwest jobber-distributors are able to buy heating oils at reasonable prices immediately and throughout the heating season, Majewski said he would ask that "thorough consideration" be given at the National Petroleum Council's October 9 meeting to a plan to allocate products and transportation east of the Rockies with approval of the Department of Justice.

Eighteenth Annual Meeting of I.P.A.A. to Open September 28

INDEPENDENT oil operators from all parts of the United States will gather in Oklahoma City September 28 for the eighteenth annual meeting of the Independent Petroleum Association of America.

Shortages of oil-field equipment, the Supreme Court's decision in the "tidelands" case, the federal Government's activities affecting the oil industry, and other current problems are scheduled for discussion on the program.

Registration will open Sunday, September 28 at the Skirvin Hotel, headquarters for the meeting. Many of the association's committees have scheduled meetings September 27 and 28.

The advance program for the meeting follows:

MONDAY, SEPTEMBER 29

10 a.m., General Session—Guy I. Warren, vice president, Renwar Oil Corp., Corpus Christ, Tex., presiding. "Welcome to Oklahoma," Roy J. Turner, governor of Oklahoma; president's annual address, B. A. Hardey, Shreveport, La.; "Unitization and Secondary Recovery," R. I. Williams, petroleum engineer, Lion Oil Co., El Dorado, Ark.; election of 1947-48 board of directors.

12:15 p.m., General Luncheon.—Edward J. Bouwsma, Commonwealth Pipe Line Co., Holland, Mich., presiding. "The Challenge to the Domestic Industry to Meet Current and Future Oil Demand," Rush M. Blodget, secretary-treasurer, Blackfoot Petroleum Co., Los Angeles.

2:15 p.m., General Session.—George Wagner Dimock, Akin & Dimock, Wichita Falls, Tex., presiding; "Objectives and Activities of the Foundation of Applied Research," Raymond J. Neumann, public-relations director, Foundation of Applied Research and Institute of Industrial Research, San Antonio; Forum on Current Association Activities, led by Russell B. Brown, general counsel, I.P.A.A.

3:15 p.m.—Meeting of board of directors, President B. A. Hardey, presiding.

7:00 p.m., Annual Dinner.—Frank Buttram, Oklahoma City, presiding. "Importance of the Trade Association in Industry," James L. Donnelly, executive vice president, Illinois Manufacturers Association, Chicago.

TUESDAY, SEPTEMBER 30

10 a.m., General Session—T. M. Martin, vice president, Lion Oil Co., El Dorado, Ark., presiding. Discussion of resolutions presented by resolutions committee; discussion of reports and resolutions offered by standing and special committees.

12:15 p.m., Governors' Luncheon.—Gov. Roy J. Turner, Oklahoma, presiding. "The Effect of the Recent Tidelands Decision," Price Daniel, attorney general of Texas, Austin; and visiting governors of oil-producing states.

2:30 p.m., General Session.—J. Ed Warren, King, Warren, & Dye, Midland, Tex., chairman, oil-field material-shortages committee, presiding. Material-shortage forum, "The Industry Demand for Tubular Goods," Warren Baker, editor, World Oil, Houston; "Current and Future Availability of Materials to Meet This Demand," W. F. McConnor, vice president in charge of sales, National Tube Co., Pittsburgh; discussion period.

4:00 p.m.—Meeting of executive committee and vice presidents.

5:00 p.m.—Barbecue, courtesy, Oklahoma Landmen's Association.

John C. Calhoun Now Author Of Engineering Fundamentals

STARTING with this issue, Dr. John C. Calhoun becomes author of the Journal's popular Engineering Fundamentals feature. A wide scope of subjects will be presented in a series especially prepared for the Journal. Subject matter will include practical problems and solutions in order to be of ready use to operating and field engineers.

Dr. Calhoun is a member of the petroleum-engineering faculty of University of Oklahoma. He was educated in Pennsylvania and received the degree of bachelor of science in petroleum and natural-gas engineering at Pennsylvania State College. He also received degrees of master of science and doctor of philosophy from that institution. His oil-industry experience includes work for Olean Petroleum Co., Shell Oil Co., Inc., and resident engineer at Bradford, Pa., doing liaison work between the Penn State secondary-recovery laboratory and field operations. Dr. Calhoun is a member of A.I.M.E., American Chemical Society, Sigma Xi research society, Sigma Kappa Epsilon geological society, and is author of numerous papers and reports on petroleum engineering, secondary recovery, and reservoir engineering.

International

WORLD-WIDE OIL DEVELOPMENTS

Plans Moving Ahead for Second Middle East Pipe Line

AN eastern Mediterranean port in the immediate vicinity of Tartus, in Latakia, is probably destined to be an equally prominent Middle East crude-oil terminal along with Sidon and Tripoli, in Lebanon, and Haifa in Palestine, for it has been learned on good authority that a port in this area may be the terminus of the 34-36-in., 800-mile line to be built by Middle East Pipe Line, Ltd.

This is the company 50 per cent owned by Anglo-Iranian Oil Co., Ltd., with the remaining 50 per cent owned by Standard Oil Co. (N.J.) and Socony-Vacuum Oil Co., Inc. The exact percentage ownership between Jersey Standard and Socony-Vacuum has not yet been announced, although earlier reports stated that Jersey Standard will own 40 per cent.

Capacity of this second big inch Middle East line (the first being Trans-Arabian Pipe Line Co.'s 30-31-in. line from Saudi Arabia's Abqaiq field to Sidon) will be between 500,000 and 560,000 bbl. daily.

This line will originate near the Persian Gulf at a point 25 miles from the border of Kuwait and 75 miles from the Iranian Frontier. The feeder line will bring crude oil from the Island of Abadan and the prolific Burgan field in Kuwait. Whether Gulf Oil Corp. and some Royal Dutch-Shell interest will ship Kuwait crude through this line cannot be determined, but authoritative sources admit it is a good possibility. Gulf and Anglo-Iranian jointly hold the Kuwait concession.

Six Pumping Stations

Construction of six pumping stations is now being considered for this line with the completion date set for January 1952. It will probably be summer 1949 before Consolidated Steel Co. completes rolling the 30-31-in. pipe for Aramco and starts work on the 34-36-in. pipe for Middle East Pipe Line, Ltd. Owners of the latter projected pipe line anticipate a relatively easy problem in obtaining rights-of-way in that only two countries, Iraq and Syria, will be crossed. Latakia is considered part of Syria.

Plans are being formulated by Iraq Petroleum Co., Ltd.—plans which so far are only in the early stages—for construction of still a third big inch line in this area. This is the 30-32-in., 500-mile line from Iraq's Kirkuk field to the Mediterranean. The ocean terminus for this line probably will be in Latakia in the neighborhood of Tartus, or possibly in Lebanon at Tripoli. With two pumping stations, the daily crude-oil capacity of this line will be 270,000 bbl. Completion of the line is anticipated for sometime in 1955.

The combined capacity of all Middle East to the Mediterranean crude-oil pipe lines, by 1955, will be at least 1,350,000 bbl. daily. Whether Trans-Arabian steps up its initial capacity of 300,000 bbl. daily by 1955 has not yet been determined. Trans-Arabian's capacity might be increased by adding more pumps at the six pumping stations, with loop lines, or Trans-Arabian might also install intermediate booster stations.

Trans-Arabian's pipe line capacity might be increased by either method to approximate 450,000 bbl. daily. Looping would be more economical.

Russian Concession in Iran Seen as Unlikely

THE probability that Soviet Russia will obtain an oil concession from the Iranian Government in the near future appears rather doubtful, despite the fact that the British Foreign Office has officially stated that oil-concession negotiations with Moscow should continue.

Developments over the next few weeks may appear in the following order, a well-informed source predicted: (1) Iran's Parliament will reject the proposed Soviet-Iranian oil concession on the grounds that Russia violated a 1943 pledge not to seek an oil concession while her troops were in Iran; (2) Iranian's Premier Ahmed Ghavam will "keep the door open" for a new Russian oil concession; (3) the projected new concession will be hedged with provisions which Russia will not accept.

What happens after this appears uncertain. The Iranian Government will observe the diplomatic amenities, knowing that she has the strong support of the United States.

In Moscow the Russian Government asserted that failure to ratify the concession would be considered "a return to the policy of enmity toward and discrimination against the Soviet Union."

Britain's Position

In defending Russia's right to negotiate for an oil concession, the British Government (which owns 56 per cent of Anglo-Iranian Oil Co., Ltd.) takes the position that the Soviets should not be excluded from Iran. However, it is known that the British Foreign Office frowns on the method Russia used to obtain the projected concession.

Britain's stand is easily comprehensible. In the first place the British would not want an oil concession as close to Russia as the proposed Soviet concession in Azerbaijan. Secondly, the British have considered southern Iran as a sphere of influence, and Russia has taken a somewhat "official" stand that it holds equal rights in the north.

Commenting on the Iranian-Russian oil controversy, one source in New York last week stated that "if it were not for the stupidity of Moscow the chances of Russia obtaining an Iranian oil concession would be good." He added that with the strong support of the British Government, the Soviets probably would have the concession now. But Russia's strong-arm tactics may result in an Iranian refusal to concede to any terms—at least for some time to come.

Expansion Plans Indicate Scope Of Industry Operations in 1951

THE year 1951 appears to be significant for the world's petroleum industry. By that time over-all demand for crude oil and products will have reached an estimated 10,300,000 bbl. daily. And sufficiently expanded operations in all phases of the industry presumably will be meeting this all-time high demand. The role of Middle East oil will be dominant.

In a preview of what may be expected, generally, and what Standard Oil Co. (N.J.) and its affiliates will be doing specifically, the current issue of The Lamp, company publication, states that Jersey Standard and its affiliates throughout the world are in the midst of one of the greatest expansion programs in the company's history. *(For Jersey Standard's statement regarding its domestic expansion, see page 153).*

Barring unforeseeable delays Jersey Standard expects that by 1951 many of its construction and expansion projects will be completed.

Another note indicative of the near future was in the brief statement of Standard Oil Co. of California to the effect that "with a continued growth in demand for crude oil and products, we can anticipate the necessity of future imports of crude oil on a rising scale to supplement domestic supply."

To meet its world comitments, California Standard, in partnership with The Texas Co., is rapidly expanding its tanker subsidiary company, Overseas Tankship Corp. Overseas Tankship now has in service a fleet of nearly 50 owned and chartered vessels (about 44 owned), and further expansion is planned. It is not yet generally known that within the next few years Overseas Tankship probably will be the largest fleet tanker company in the world.

Tanker Being Voyage Chartered

Only recently the S.S. Ulysses—the world's largest tanker—started carrying petroleum products. This tanker, with a deadweight tonnage of 27,928, carries between 190,000 and 200,000 bbl. of petroleum products. Owned by the National Bulk Carriers, the tanker is being voyage chartered. Currently, Standard-Vacuum Oil Co. has the tanker under charter carrying products from Bahrein Island and Ras Tanura, in the Persian Gulf, to Capetown, South Africa.

Reliable reports state that more tankers, similar in size and carrying capacity of the Ulysses are now being planned. Many of them presumably will operate in the Middle East trade. National Bulk Carriers is among the shipbuilders planning to build larger tankers. One, now under way at the Welding yards in Norfolk, will have a capacity of approximately 240,000 bbl.

The purchase of a second group of 20 T-2 tankers from the U. S. Maritime Commission, by Overseas Tankship has been authorized, California Standard said. The O.T.C. fleet is engaged in transporting crude oil and products from Saudi Arabia and Bahrein Island to markets in the Eastern Hemisphere.

It will probably be 1948 before the much-discussed Marshall Plan gets under way. This calls for approximately 70,000,000 tons (about 1,400,000 bbl. daily) to be supplied to the 16 Western European countries embraced by the plan. This represents an increase of around 650,000 bbl. daily over what is being delivered now. One half of the increased demand presumably will come from the sterling areas and one half from dollar sources.

Caribbean Area's Part

The Caribbean as a whole, and Venezuela in particular, today are supplying 50 per cent of Europe's oil imports, The Lamp points out. The magazine explained that "although further increases in European demand, which in 1951 is expected to be 63 per cent over 1946, will be met chiefly by oil from the Middle East, Caribbean production is expected to rise more than 350,000 bbl. a day and refinery capacity nearly 200,000 bbl. daily."

Jersey Standard's refinery construction plan in Europe calls for increasing the Agwi Petroleum Corp.'s Fawley plant in England, from 13,000 bbl. daily to 120,000 bbl. daily at a cost around $140,000,000. As a result of cutting many corners to achieve volume, the Port Jerome refinery of Standard Francaise des Petroles in France has been increased to 25,000 bbl. daily. The replacement of facilities destroyed or stolen by the Nazis during the war is required before prewar quality standards are resumed at Port Jerome.

In fact, reconstruction problems to those at Port Jerome, exist all over Europe The Lamp says, explaining that an "immediate aim of expansion efforts of Jersey affiliates is to help make available as quickly as possible the fuels and lubricants needed to restore other industries to maximum productive capacity."

Creole Petroleum Corp.'s Amuay Bay refinery, in Venezuela, will include a catalytic cracking unit similar to the new unit to be constructed at Bayway, N. J., and will process 60,000 bbl. daily. Currently construction of a 300,000-bbl. daily crude-oil pipe line is under way from the Lake Maracaibo fields 150 miles away. For 14 miles across the Coro Gulf it is to be buried in an underwater trench dug by dredges. All dispatching, for the first time on any major pipe line, will be done by FM radio.

Target date for limited operation of Standard-Vacuum Oil Co.'s Palembang refinery, in Sumatra, Netherlands East Indies, is this fall and for capacity operation (if crude is available) a year later. Major expansion plans there have been deferred until Indonesia's political and economic future is settled.

Portugal Plans Survey of Nation's Refining Capacity

Sacor, the Portuguese Petroleum Refining Co., has been asked to make a survey of existing refining capacity in Portugal with a view to increasing fuel oil production. The request was made by the minister of economy, according to a Reuters dispatch from Lisbon.

Sacor reportedly has discontinued the production of asphalt and lubricating oil to concentrate on the manufacture of fuel oil. To supply the country with the necessary amounts of asphalt and lube oils, the authorities have decided to free imports and trade in such oil from all controls until January 31, 1950.

Seventh Spring Hill Test Shows 750 Bbl.

A flow test on Chile's seventh test well, in Spring Hill field, Tierra del Fuego, showed a daily potential of at least 750 bbl. daily. The top of the producing sand has been touched in the eighth well at a depth of 7,174 ft., but results of a flow test were not known late last week.

As there are no storage tanks at Spring Hill, flow tests have been of short duration.

Danish Test at 2,500 Ft.

Danish American Prospecting Co., an affiliate of Gulf Oil Corp., is down to approximately 2,500 ft. in a wildcat being drilled near Holstebro, Jutland. Casing was set at 1,840 ft. Projected depth is around 8,500 ft.

Large-Scale Exploration Program Outlined for France

by Claude Dufresne

IN order successfully to carry out her modernization program, France must solve the problem of power and fuel supply. Before the war French economy, a relatively small consumer of power, was backward in comparison with that of other countries, particularly the United States. A worker in France could utilize only 7,500 hp. hours a year, while a worker in Great Britain or the United States utilized 20,000 hp. hours and 33,500 hp. hours respectively. Even at this rate of consumption, France was obliged to import one-third of the power she consumed.

Power can be imported in the form of coal or in the form of oil. Since 1927, France has held uncontested rights to large oil-producing properties in Iraq, from which French Petroleum Co. (Cie. Francaise des Petroleos) has up to now obtained an average of only 1,000,000 tons of oil a year (about 7,000,000 bbl.). From 1948 on, these fields should produce 3,000,000 tons a year (about 21,000,000 bbl.) and negotiations now being carried on in London indicate that France will obtain oil from the Middle East in quantities commensurate with her needs, as soon as the construction of large capacity pipe lines is completed. In addition to this, a number of foreign companies operating oil refineries in France have access to large oil supplies in the Middle East.

Oil Supplies Answer

Oil, therefore, seems to be the answer to France's immediate power problem, and it is essential that a serious attempt be made to increase her sources of supply by exploring all possible oil-bearing regions in France and the countries of the French Union. With this in view, the Fuel Commission of the Monnet Plan has outlined a 10-year oil-prospecting program and listed the conditions essential to its realization. These include the provision of adequate and sustained financial support, the training of skilled personnel, the expansion of French manufacture of oil-drilling equipment, and the simplification of government regulations.

The first stage in the exploration program for Metropolitan France is the prospecting of 100,000 sq. km. (about 38,600 sq. miles) which have already been surveyed and the drilling of 280,000 m. (920,000 ft.) within the next 6 years.

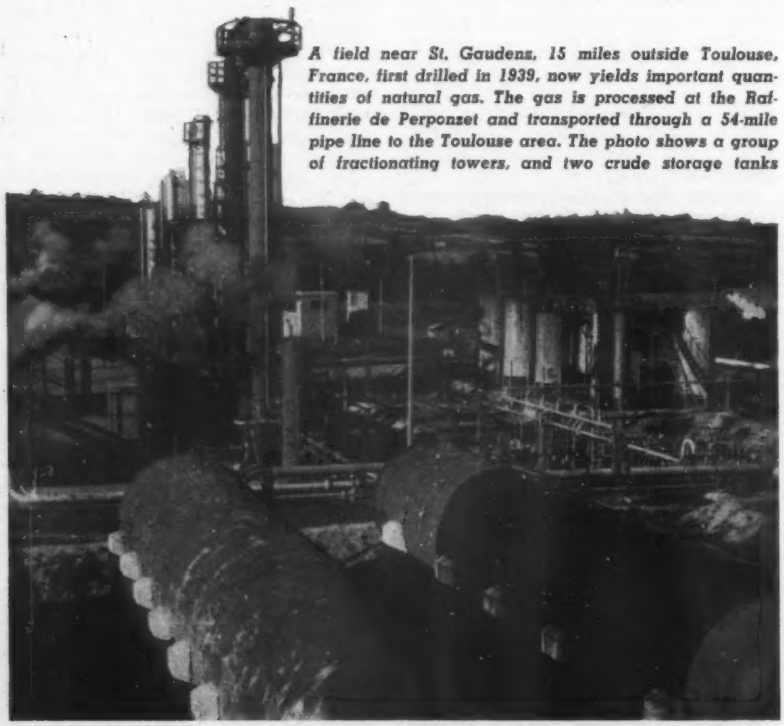
For North Africa, first, the prospecting of 190,000 sq. km. (about 73,000 sq. miles) and drilling of 360,000 m. (about 1,180,000 ft.) within 6 years; second, continued operation of the same wells and drilling of 190,000 m. (about 620,000 ft.).

For other parts of the French Union, first, prospecting and drilling of 50,000 sq. km. (about 19,300 sq. miles) in the Gabun; prospecting of 60,000 sq. km. (about 23,200 sq. miles) and drilling of 145,000 m. (about 475,000 ft.) in Madagascar, the French Cameroons and New Caledonia, within the next 5 years. Second, prospecting of an additional 400,000 sq. km. (about 155,000 sq. miles) and drilling of 2,000,000 m. (about 6,550,000 ft.) before the end of a 10-year period.

Division of Risks

A program of this scope makes it imperative to divide the risks involved and to place investments in those countries which are known to possess rich resources. While it has not attempted to calculate the exact figure of present oil investments abroad, the Fuel Commission estimates the amount as approximately one-half the sum invested in the French Union, that is, at twenty billion francs. In 10 years, foreign investments amounting to 60 billions are envisaged. The French Petroleum Co. already has large investments in Venezuela.

Another problem remains to be solved, that of the shipment of oil imports. This depends upon maritime transport facilities. The French oil fleet formerly numbered 35 tankers, with a total tonnage of about 400,000 tons, and capable of transporting 3,000,000 tons of petroleum products or 40 per cent of France's total oil imports. The remaining 60 per cent was carried in foreign tankers at an annual cost to France of 800 million francs in foreign exchange.



A field near St. Gaudens, 15 miles outside Toulouse, France, first drilled in 1939, now yields important quantities of natural gas. The gas is processed at the Raffinerie de Perponzet and transported through a 54-mile pipe line to the Toulouse area. The photo shows a group of fractionating towers, and two crude storage tanks

France now possesses only 16 oil tankers with a total tonnage of about 200,000 tons. This figure will rise to 300,000 tons by the end of 1947, when a number of salvaged ships now under repair, and tankers for which orders were placed abroad before the war, are brought into service. Taking all these considerations into account, the Fuel Commission of the Monnet Plan estimates that in the future the French oil-tanker fleet should be able to carry at least 50 per cent of the crude and refined oil products that France needs to import. New tankers must be built on the same model as those of foreign countries, so that France may compete on the world freight market. Vessels of 16,500 or 21,500 tons and, eventually, of even greater tonnage—for the transport of crude oil from the Middle East to Le Havre or Marseilles—will be required to provide the 600,000 tons that France needs. This part of the moderinzation program demands heavy expenditures, but it will make possible substantial savings of foreign exchange, since the utilization of a single French-owned 16,500-ton oil tanker represents a saving of over $800,0000 a year.

France has the choice of importing petroleum either in a refined state or as crude oil to be processed by her own refineries. The capacity of the oil refining plants in France has been greatly reduced as a result of war damages and the loss of machinery carried off by the Germans. Thanks to an energetic reconstruction effort started immediately after the Liberation, this capacity was increased from 1,800,000 tons (about 34,500 bbl. daily) as of August 1945 to 3,000,000 tons by May 1946 (about 57,500 bbl. daily). Work now in progress, consisting mainly of final adjustments of repaired machinery, will be completed by the end of 1947, and French refineries will then be able to process approximately 5,000,000 tons a year.

Refinery Modernization

The oil refineries will then enter upon the phase of modernization, as contrasted with that of mere repair and reconstruction. It is expected that, by 1950, they will be able to handle 10,000,000 tons (about 192,000 bbl. daily) of crude oil and, by 1955, 15,000,000 (about 288,000 bbl. daily). The latter figure should provide 13,000,000 tons (about 250,000 bbl. daily) of refined oil products for consumption.

In determining the location and extent of new or modernized installations, the following factors were considered to be of primary importance: the ability of port installations in each area to receive imports of crude oil, the geographical distribution of French consumption, and the means of internal transport and the location of the sources of supply. The commission also considered it necessary to plan the construction of refineries and other installations that can operate at production costs comparable to those of the great oil-producing countries. This means the construction of refineries capable of processing 1,000,000 tons of crude oil per year (about 19,000 bbl. daily) *(For other details on the Monnet Plan for French refineries, see The Oil and Gas Journal, February 22, 1947, page 106)*. These considerations led the Fuel Commission of the Monnet Plan to draw up the following schedule to be achieved by French refineries by 1955:

(Figures in tons annually. One ton equals about 7 bbl.)

Dunkerque—oil refinery	1,400,000
Lower Seine region—combined installations	5,700,000
Lower Loire region—combined installations	800,000
Gironde—oil refinery	900,000
Mediterranean—combined installations	4,150,000
Total	13,000,000

Creole's July Output Highest Since March

VENEZUELAN crude-oil production of Creole Petroleum Corp. climbed back to 594,023 bbl. during July, the highest daily production rate since the company produced 594,544 bbl. daily in March. Creole's all-time high was 599,192 bbl., a mark set last February. Of the July total, 442,051 bbl. came from Lake Maracaibo area and Cumarebo, and 151,972 bbl. from Eastern Venezuela.

Creole refined 67,815 bbl. daily in July, compared with 66,818 bbl. daily in June. Of the July refinery output, 59,010 bbl. came from Caripito and 8,805 from the La Salina refinery.

Nineteen development wells were completed, all oil producers, and one wildcat, a dry hole. The latter was drilled to 4,150 ft. in the Jusepin area. The fields where the producers were brought in, their average initial production, and average depth follow:

Bolivar Coastal (B.C.F.), ten, 605 bbl., 4,335 ft.; Jusepin, three, 174 bbl., 4,542 ft.; Mulata, three, 360, bbl., 5,075 ft.; and Quiriquire, three, 458 bbl., 3,709 ft.

In West Lake, Shell's VL-1 well is being drilled by Creole.

Greece Receives Oil Shipment

An American shipment of 95,000 bbl. of oil arrived recently in Athens, Greece, on a United States Navy tanker. It was an emergency shipment intended for relief of the fuel shortage there.

From Athens the tanker was to proceed to the Middle East oil areas and return with another cargo.

International

Hungary Earmarks Fund For Oil Exploration

IN an effort to increase Hungarian oil production, Hungary's Russian-dominated government has initiated a 3-year plan which calls for a large-scale search for new oil reserves. Approximately $4,880,000 has been earmarked for exploratory activities, according to a Reuters dispatch.

Due to overproduction of Hungary's fields by the Nazis during the war and Russia's insistence on identical production methods since the war, Hungary's output is steadily dropping with further declines forecast for the immediate future.

Hungary's estimated average refinery yields for 1946 are compared below with the projected decreased output of the major petroleum products for 1950, the last year of the 3-year plan:

(All figures in metric tons)

	1946	1950
Gasoline	205,000	170,000
Kerosine	123,000	143,000
Gas oil	93,000	73,000
Lubricants	4,000	45,000
Fuel oil	160,000	69,000
Totals	585,000	500,000

A higher yield of kerosine has been aimed at, presumably to take care of the vastly increased demands of mechanized farming. The projected annual manufacture of 45,000 tons of lubricants, compared with a 4,000 ton output in 1946 and an 18,000 ton over-all annual prewar demand, appears to be over estimated in view of the existing refinery equipment.

With an increased postwar demand already for petroleum products and with lower refinery yield forecast, it is difficult to see how Hungary will meet the requirements of expanded industrialization called for under the 3-year plan.

Japanese Report Major Oil Discovery

Discovery of what is claimed to be Japan's largest oil field near Teshio on the northwest coast of Hokkaido, has been reported by Japanese newspapers.

It was reported the Japanese Imperial Petroleum Co. soon would start two test wells 6,500 to 8,000 ft. deep in the area which is said to be 30 miles wide and extend out into the sea bed.

Production in the newly discovered district previously has been on a small scale.

No Concerted Opposition Develops To Railroad Increases

WASHINGTON.—One of the apparently surprising things is the seeming lack of interest displayed by representatives of the oil industry here in the prospect of a large increase in tank car and other rates increasing the cost of delivering petroleum products.

These freight boosts will follow if the Interstate Commerce Commission approves the requests of the nation's railroads for increases up to 27 per cent (more in some areas, less in others). These proposed freight rate increases are now pending before the ICC.

So far as it can be determined now, no concerted opposition has developed in the oil industry in opposition to the increases.

For this apparent apathy, however, there are probably two explanations.

For one thing, it is regarded as a certainty that rates will be increased, although probably not to the full average of 27 per cent. The ICC seldom grants the full amount of requested increases. The railroads' case has wide sympathy. Successive advances in rail labor wages approved by arbitration boards, plus the rising cost of steel, coal, and equipment, make it imperative, in the viewpoint of the majority of observers here, that the roads be permitted to charge more as the price of avoiding bankruptcy.

For another thing, while the cost of transporting oil will rise, the cost of moving coal also will rise, leaving the petroleum industry at no necessary disadvantage with its chief competitor.

One source pointed out, however, that regardless of this even handedness, a number of "land-locked" refineries probably will face the prospect that with higher costs they will have to contract their areas of distribution.

There is every expectation that the ICC will approve promptly the proposed emergency or stop-gap rate increase of 10 per cent. This will permit the roads to avoid some of their losses while the larger issue of the total amount of rate increases is debated more deliberately.

Under the proposed increases, many petroleum products would be subjected to a series of increases up to a maximum of 9 cents per 100 lb., but this maximum would apply only to movement in tank cars. The full percentage increases, without any maximum, would apply on movements of "packaged" petroleum products, such as in drums or other metal containers. Gasoline, kerosine, fuel oil, and a number of other petroleum products would be subjected up to the maximum charge of 9 cents per 100 lb. On lubricating oils, carriers would charge the full increase in the percentage boost allowed.

Research Institute Dedicated in Texas

THE Southwest Research Institute, an organization for endowed scientific study founded by Tom Slick, was dedicated September 11 on the Essar ranch 7 miles from San Antonio.

The new laboratory includes chemical and biological units, engineering department, and a complete machine shop. The second laboratory of the institute, it was made known at the dedication, is expected to be in Houston, devoted to petroleum chemistry and technology. Construction probably will start in about 6 months.

The Southwest Research Institute is the third and final part of a research organization which also embraces the Foundation of Applied Research, now working on agricultural and medical studies, and the Institute of Inventive Research, which aids inventors in developing their ideas.

A number of prominent oil operators and company executives, particularly from the South Texas area, attended the dedication. Slick, a San Antonio oil operator and rancher, and son of the late Tom Slick, Sr., told the group that "we are trying to design an organization to be of service to our entire southwestern area. We want the various communities in this area, particularly Houston with its great industry development, to feel that our organization is theirs as well as San Antonio's. It should provide a vital research service to the industry of our area, both to large and small businesses."

Tulsa Hearing Postponed By Senate Committee

The Tulsa hearing of the petroleum subcommittee of the Senate small business committee, originally scheduled for September 29, has been indefinitely postponed. The hearing has been called off because of the Independent Petroleum Association of America meeting at Oklahoma City September 28-30.

Earlier last week Bernard L. Majewski, vice president of Deep Rock Oil Corp. strongly attacked the practices of the subcommittee, declaring that it "cannot be classed as a fact-finding enterprise and is a waste of taxpayers' money . . . and serves to reduce the prestige of Congress."

Price Investigation in Washington Called Off

WASHINGTON.—The federal grand jury investigation of gasoline prices in Washington, and which department officials insist is purely a local matter, has suddenly been called off and the jury dismissed with the statement that its work was "significant." However, U. S. District Attorney George Morris Fay said in a final report that continuation of the inquiry was recommended.

In the 2 weeks of investigation, the grand jury heard 30 witnesses from most of the major oil companies operating in the capital, the Retail Gasoline Dealers Association, Inc., and a number of independent dealers.

Ohio Standard Acquires Two New Oil Properties

Standard Oil Co. (Ohio) is arranging to acquire most of the outstanding stock of Aylward Production Co. and Felmont Corp., both independent producing companies which had a combined daily average net crude production of about 3,000 bbl. last June.

Aylward Production Co., located in Wichita, Kans., has production in 68 producing oil and gas leases in Kansas, Illinois, and Oklahoma. Felmont Corp. has interests in 77 producing oil and gas leases, most of which are in Illinois.

American Independent Oil Opens Washington Office

American Independent Oil Co., the newly organized corporation headed by Phillips Petroleum Co., has established its Washington headquarters at 1625 K Street, N.W. This is the same building in which Phillips has its Washington office, as well as the American Petroleum Institute and the National Petroleum Council.

Reno Buys Beacon Refining

Reno Oil Co., Sistersville, W. Va., with headquarters in Wichita Falls, has purchased the oil-producing properties of Beacon Refining Co., Henderson, Tex. Production is in Archer, Montague, Wilbarger, and Young counties.

Battle for Middle Distillates A Major Refining Problem

by Arch L. Foster

PRODUCTION of middle distillates in quantities much greater than the 288,000,000 bbl. of gas oil and distillate fuel oils made in 1946 is proving to be a potential, and in many cases an actual, headache to the nation's refiners, a survey of the industry indicates. Similarly, the production of anywhere from 90 to 110 million barrels of diesel fuels annually, half of which will be higher quality products for high-speed diesels, adds seriously to the complicated structure which is the three-way job of refining and marketing products from the middle distillates.

This three-way refining job is an old story, but it is complicated in this postwar era by the accumulated and increased demand. In a word, the refiner has three outlets, and now three overgrown demands, for the middle fraction of his barrel of crude: (1) as charging stock for thermal or catalytic cracking; (2) as furnace oil to heat homes and buildings; and (3) as diesel and tractor fuel, to motivate the nation's industrial, railroad, marine, and heavy automotive power plants.

According to figures of the American Petroleum Institute, production of gas oil and middle distillates, or distillate fuel oil, in 1946 was 287,896,000 bbl. At the same time, 104,385,000 bbl. of kerosine was produced.

Yields of cracked gasoline vary widely, but to assume for convenience a 50 per cent yield on the charge stock, last year's 390,200,000 bbl. (approximately) of cracked gasoline consumes about 780,000,000 bbl. of gas-oil charge. This amount, of course, is not included in any part of the reported yield of 287,896,000 bbl. reported above.

Reason for Pinch

By reference to Table 1, one reason for the pinch is evident; furnace-oil consumption has grown by leaps and bounds. The staggering total of 7¼ billion gallons, or about 173 million bbl., estimated for 1950 is well above half the total reported gas-oil production for 1946.

An even better comparison between prewar and postwar demand for distillate fuel oils is shown in Table 2. It is seen from these Bureau of Mines figures the increase in demand in the current year is 64 per cent greater than in 1941. An increase so astounding as this of necessity puts a great burden on the refining industry.

John W. Boatwright, Standard Oil Co. (Ind.) in a talk before the Cleveland Chamber of Commerce last year, predicted demand for all distillate fuel oils will total 820,000 bbl. daily by 1951, a 74 per cent increase over 1941.

One of the most insistent and demanding outlets for middle distillates is diesel fuel. Figures in Table 3 show the pressure that is being placed on refiners to provide suitable fuels in quality and quantity for the increase in diesel horsepower in this country.

Most outstanding increase, doubtless, is that of railroad diesels. From 2,752,000 bbl. in 1941, when diesel-electric locomotives were already widely used, to an estimated 26 million bbl. in 1951 is a rise worthy of notice.

Boatwright believes that the 1947 consumption of all types of diesel fuels will total 72,000,000 bbl., or 163 per cent above the 1941 consumption figures.

The great leap in diesel power going into service is of course in relatively high-speed diesels, railroad, automotive, etc. A. J. Blackwood, of Standard Oil Development Co., reported last June to the Society of Automotive Engineers that 91,000 bbl. of diesel fuel will be consumed per day in high-speed diesel engines during 1947, or 33,200,000 bbl. for the year (Table 4). His estimate for the consumption of similar fuels for 1951

TABLE 1—DOMESTIC OIL BURNERS AND FURNACE-OIL CONSUMPTION

Year—	Average No. of burners operating	Furnace-oil consumption (in gallons)
1936	1,246,400	2,916,018,000
1937	1,435,610	3,411,870,000
1938	1,599,150	3,460,296,000
1939	1,765,040	4,079,502,000
1940	1,998,730	4,952,386,000
1941	2,268,590	5,078,136,000
1942	2,394,180	5,103,252,000
1943	2,385,370	4,534,404,000
1950 (est.)	.....	7,256,928,000

From "Retail Marketing of Furnace Oil," by Harvey P. Bishop.

TABLE 2—DEMAND FOR GAS OIL AND DISTILLATE FUEL OIL

	Domestic	Exports	Total
1941 First quarter	58,640,000	3,414,000	62,054,000
Daily average	651,600	37,900	689,500
1947 First quarter	96,260,000	5,423,000	101,683,000
Daily average	1,069,600	60,200	1,129,800
Per cent increase for 1947	64.15	58.84	63.86

TABLE 3—ACTUAL AND FORECAST DEMAND FOR DIESEL FUEL

(1,000 bbl. per year.)

	Actual 1941	Estimated 1946	Forecast 1951
Railroads	2,752	13,900	25,925
Vesseles—Marine	10,571	11,685	15,963
Industry, commercial and miscl.	1,819	3,744	6,701
Smelters, mines, mfg., etc.	3,199	6,909	10,485
All others	6,167	10,870	15,680
Tractor fuel	.....	4,100	4,800
Oil companies	238	411	750
U. S. Army—Navy C. G.	2,605	14,780	6,085
U. S. total	27,351	66,399	86,389
Totals excluding government	24,746	51,619	80,304

Basis: Bureau of Mines figures.

TABLE 4—DOMESTIC DEMAND FOR HIGH-SPEED DIESEL FUEL

Use—	Demand (in barrels) Per day 1947	Per year 1947	Per day 1951	Per year 1951
Buses	4,000	.....	7,000	.....
Trucks	10,000	.....	17,000	.....
Tractors, constr. mach.	30,000	.....	36,000	.....
Railroads	47,000	33,215,000	84,000	52,560,000

From S.A.E. paper, June 1947, by A. J. Blackwood, Standard Oil Development Co.

TABLE 5—INSTALLED DIESEL HORSEPOWER AS OF JANUARY 1, 1947

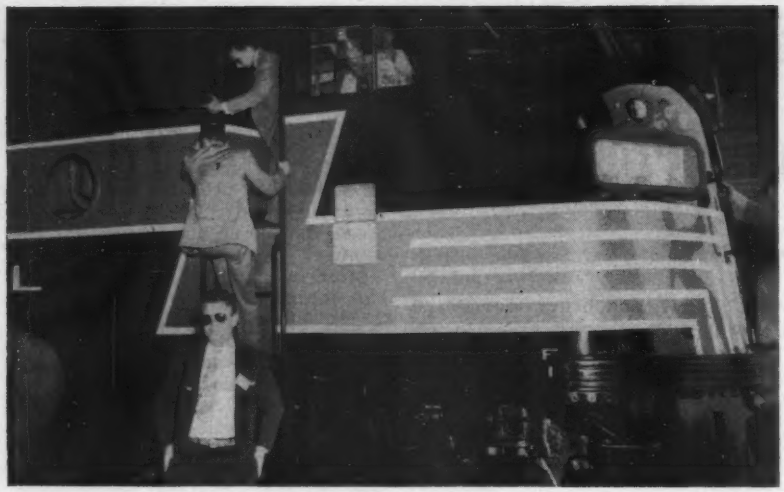
Service—	Horsepower	Engine units
Railroads, (4,165 locomotives)	5,000,000	8,330
Motor trucks	1,950,000	13,000
Motor buses	879,250	5,860
Tractors and contractors' machinery	7,997,000	40,000
Oil industry	720,000	3,600
Marine	3,725,400	20,100
Municipal power plants	2,460,000	4,100
General industry	15,000,000	25,000
Mining, quarrying, lumbering and agricultural processing	1,745,000	7,000
Industrial locomotives	1,600,000	8,000
Total	41,076,650	134,990

The above breakdown is exclusive of military horsepower. (From Diesel Power and Transportation).

TABLE 6—OIL-BURNER SALES FORECAST

Year—	Conversions from coal	New homes	Replacements	Total
1946	284,000	62,000	74,000	420,000
1947	297,000	103,000	66,000	466,000
1948	307,000	132,000	68,000	507,000
1949	322,000	132,000	80,000	534,000
1950	334,000	132,000	100,000	566,000
Total	1,544,000	561,000	388,000	2,493,000

From Robert Gray.



A greatly expanding diesel-power industry is adding to the demands being placed on the petroleum refining industry for its production in the middle-distillate range. Indicative of the increasing interest in the diesel-power field was the conference held during the summer for college mechanical engineering instructors in Chicago by the Diesel Engine Manufacturers Association. The professors toured several diesel-engine manufacturing plants. This photo shows William Rudoy, University of Pittsburgh (emerging from cab) and Frank T. Carroll, Jr., Louisiana State University (standing on floor) inspecting a diesel freight locomotive under construction for New York Central Railroad at the Electro-Motive division of General Motors Corp., LaGrange, Ill.

is 144,000 bbl. per day, or 52,560,000 bbl. annually.

Different classes and types of diesel engines installed in the United States as of January 1, 1947, are given in Table 5. Five million horsepower of diesel engines, in 4,165 double-engine units show how the railroads are going. In addition 8,000 engines are installed in industrial locomotives, either as diesel-electric or as direct diesel-driven power plants. Engines in motor trucks, and buses, and in tractors, etc., may be considered to be high-speed, along with locomotive diesels, and thus to require better-grade fuels. The remainder of this listing, which does not include military horsepower, may range from the slowest speed heavy-fuel, electric-generating units to still other high-speed units in general industry and elsewhere.

Furnace Oil Demand

The data in Table 6 from Robert Gray's November 1946 A.P.I. paper on "Distillate Heating Oil Outlook," show that new burner sales between 1946 and 1950 will double the number in 1945, unless oil supply becomes so critical that the new burners are not bought because of fuel scarcity and uncertainty of supply.

Cracked recycle oil can be used for certain purposes with a fair-to-good degree of success. Data published on refinery operations show that yields of light and heavy gas oils may range from 27 per cent to about 60 per cent, with an arithmetical average of about 44 per cent in catalytic cracking. Assuming that these averages will hold in 1950-51, from the 780,000,000 bbl. of cracking charge estimated above, yields of recycle gas oil, salable as furnace and even as diesel fuels, may range from 210,300,000 bbl. to 468,000,000. At the same time motor-fuel production may range from 35 per cent to more than 50 per cent—some technologists say up to 65 per cent or more. Since thermal cracking produces a large part of motor fuel, the recycle-oil transform is poor diesel fuel. If these assumptions are of the correct order of magnitude, the supply of virgin and recycle middle distillates appears to be adequate for all demands prognosticated for the next several years. However, so many variables in demand, crude runs, etc., are in the realm of possibility that no estimates can be made with safety.

One of the large unknowns in the middle distillate fuel consumption equation is that of gas turbine, turbo-jet and turbo-propeller engines to which our armed forces are giving so much research and development attention. Little is known of exact figures, but it is known that huge plans are afoot for powering our war planes with the superengines now under rapid development. It is understood that fuels for these power plants are not the type used in World War II, but are more of the wide-cut kerosine range. Demand for fuels for experimental purposes is reported increasing at a very rapid rate. In the event of a war in the next few years, it is reasonable to expect, leading authorities say, that we shall need at least as much of this fuel per day as the amount of the more usual types required at the height of the recent war. A large peacetime development could change the picture of total demand on the middle distillate radically, and make our present estimates entirely incorrect.

Within these limitations, therefore, it appears that we may expect to have available an adequate supply of middle distillates to meet the necessary uses for these fractions, during the next several years, provided the demands for each major use do not exceed greatly the estimates as foreseen by our leading economists. One of the problems yet to be solved, which may make for short supplies in many localities at different times for varying periods, is that of transportation. To solve some of this problem, refining capacity is being enlarged more and more on the Gulf, Atlantic and Pacific coasts. This development places the finished product supplies either on ocean waterways or near huge consumption centers.

A.I.M.E. Completes Regional Programs

THIRTY-FOUR papers dealing largely with a wide range of technical engineering problems in the drilling and production fields are scheduled on the programs of three important regional meetings to be held by the Petroleum Division of the American Institute of Mining and Metallurgical Engineers during October.

First of the meetings is that to be held at the Shirley Savoy Hotel in Denver September 28-October 2 with the Colorado local A.I.M.E. section as host. Next is in Tulsa at the Mayo Hotel October 8-10 with the Mid-Continent local section as host. The third meeting will be held October 23-24 at the Elks Club in Los Angeles with the Pacific petroleum chapter as host.

Each of the meetings is expected to attract several hundred petroleum engineers and oil technologists. In addition to the technical engineering papers, the programs include several discussions of a more general nature. At the Denver meeting, E. DeGolyer, Dallas, widely known geologist, will discuss United States petroleum reserves, and Gustav Egloff, Chicago, Universal Oil Products Co., will speak on modern refining. A feature of the Tulsa meeting is a technical session on offshore drilling at which various operations will be described. The final paper on the Los Angeles program is a discussion of California's oil outlook by R. L. Minckler, Los Angeles executive vice president, General Petroleum Corp.

A number of entertainment fea-

H. C. PYLE

E. DEGOLYER

R. L. MINCKLER

J. G. BARTRAM

N. VAN WINGEN

J. J. ZORICHAK

Among the officers and speakers prominent on the programs of the three regional A.I.M.E. technical meetings during October are these six: Howard C. Pyle, Los Angeles, vice president, Bank of America, and chairman of the A.I.M.E. Petroleum Division; E. DeGolyer, Dallas, who will speak on petroleum reserves at Denver; R. L. Minckler, executive vice president, Los Angeles, General Petroleum Corp., who will discuss California's oil outlook at Los Angeles; John G. Bartram, Tulsa, Stanolind Oil & Gas Co., who will present an important paper on Rocky Mountain exploration at Denver; N. van Wingen, Los Angeles, Richfield Oil Corp., chairman of the production-technology committee which secured the Tulsa and Los Angeles papers; and J. J. Zorichak, chairman of the Rangely Engineering Committee, active in arranging the Denver program

tures also are scheduled, both for the visiting engineers and their wives. The Denver and Tulsa programs list informal dinner dances, and an annual banquet is slated by the West Coast group. A feature of the Denver program is an airplane field trip over Rangely field and to the government oil-shale plant at Rifle, Colo. Continental Air Lines, Inc., is arranging at least one special plane to fly from Tulsa to Denver for the Rocky Mountain meeting.

The final programs for the technical sessions of the three meetings follow:

DENVER MEETING

(Shirley Savoy Hotel)

MONDAY, SEPTEMBER 29

2:00 to 4:00 p.m.—"Our Petroleum Reserves," E. DeGolyer, DeGolyer & MacNaughton, Dallas; "The Past and Future of Oil Exploration in the Rocky Mountain Region," John G. Bartram, manager, exploration department, Stanolind Oil & Gas Co., Tulsa; "Refining from the Modern Point of View," Gustav Egloff, director of research, Universal Oil Products Co., Chicago.

TUESDAY, SEPTEMBER 30

9:15 to 12:00 a.m.—"Location of Water Entry Points in Oil Wells," Daniel Silverman, Tulsa, and A. R. Brown, Fort Worth, Stanolind Oil & Gas Co.; "Waters of Producing Fields in the Rocky Mountain Region," J. G. Crawford, Chemical Laboratories, Inc., Casper, Wyo.; "Application of Dipmeter Surveys," Everett F. Stratton, Houston, and Robert G. Hamilton, Tulsa, Schlumberger Well Surveying Corp.

2:00 p.m.—"Drilling-Mud Problems of the Rocky Mountain Region," D. D. Varnell, Casper, Wyo., and Willard Kimbrell, Tulsa, Baroid sales division, National Lead Co.; "Diamond Coring at Rangely," Carl J. Christensen, Stanolind Oil & Gas Co., Casper; "Performance of the Lance Creek Sundance Reservoir—A Unitized Pressure-Maintenance Project," Lincoln F. Elkins, Continental Oil Co., Ponca City, Okla., R. W. French, Jr., Standard Oil Co. (Ohio), Oklahoma City, and Wayne E. Glenn, Continental Oil Co., Ponca City.

WEDNESDAY, OCTOBER 1

9:15 to 12:00—"Oil Shale Resources of Colorado, Utah, and Wyoming," Carl Belser, U. S. Bureau of Mines, Rifle, Colo.; "Oil Shale Mining," Tell Ertl, U. S. Bureau of Mines, Rifle, Colo.

THURSDAY, OCTOBER 2

Field trip by airplane over Rangely field and into Rifle, Colo., for inspection of the United States vanadium plant and the oil-shale mining and retort plant.

TULSA MEETING

(Mayo Hotel)

WEDNESDAY, OCTOBER 8

9:00 to 12:00 a.m.—"Displacement of Oil in Porous Media by Water and Gas," Henry J. Welge, Carter Oil Co., Tulsa; "Some Results of Gas and Water Drives on a Long Core," C. R. Holmgrenn, Stanolind Oil & Gas Co., Tulsa; "A Turbulent Radial Flow Formula," J. R. Elenbaas, Michigan Consolidated Gas Co., and Donald L. Katz, professor of chemistry and metallurgical engineering, University of Michigan, Ann Arbor, Mich.

2:00 to 5:00 p.m.—"A Critical Review of Methods Used in the Estimation of Natural-Gas Reserves," Henry J. Gruy and Jack A. Crichton, DeGolyer & MacNaughton, Dallas; "Phase Relations of a Gas-Condensate Fluid at Low Temperatures Including the Critical State," C. Kenneth Eilerts, V. L. Barr, N. B. Mullens, and Betty Hinman, U. S. Bureau of Mines, Bartlesville, Okla.; "Elements of Success in Engineering," Herman H. Kaveler, Phillips Petroleum Co., Bartlesville, Okla.; "Stresses About the Bore Hole of a Deep Well," A. Dale Topping, department of mechanical engineering, and A. J. Miles, professor of mechanical engineering, Missouri School of Mines and Metallurgy, Rolla, Mo.

THURSDAY, OCTOBER 9

9:00 to 12:00 a.m.—"Mechanics of Wave Action on Structures," Walter H. Munk, Scripps Institution of Oceanography, La Jolla, Calif.; "Engineering Characteristics of the Gulf Coast Continental Shelf," M. B. Willey, chief engineer, and C. L. Graves, J. Ray McDermott & Co., Harvey, La.; "Important Considerations in Marine Construction," Adm. Frederic R. Harris, and H. G. Knox, vice president, Frederic R. Harris, Inc., New York.

2:00 to 4:30 p.m.—"Informal Descriptions of Existing Off-Shore Operations," participating companies to be announced.

FRIDAY, OCTOBER 10

9:30 to 12:00 a.m.—"Lance Creek Sundance Reservoir Performance—A Unitized Pressure Maintenance Project," Lincoln F. Elkins, Continental Oil Co., Ponca City, Okla., Richard W. French, Jr., Standard Oil Co. (Ohio), Oklahoma City, and Wayne E. Glenn, Continental Oil Co., Ponca City; "Location of Water Entry Points in Oil Wells," Daniel Silverman, Tulsa, and A. R. Brown, Fort Worth, Stanolind Oil & Gas Co.; "An Improved Water Input Profile Instrument," R. J. Pfister, Pennsylvania Grade Crude Oil Association, Bradford, Pa.

LOS ANGELES MEETING

(Elks Club)

THURSDAY, OCTOBER 23

10:00 a.m.—"A Method of Measuring Oil-Pool Performance," Carlton Beal, consulting engineer, Los Angeles; "A Critical Review of Methods Used in the Estimation of Natural-Gas Reserves," Henry J. Gruy and Jack A. Crichton, DeGolyer & MacNaughton, Dallas.

2:00 p.m.—"Location of Water Entry Points in Oil Wells," Daniel Silverman, Tulsa, and A. R. Brown, Fort Worth, Stanolind Oil & Gas Co.; "Experimental Production Projects and Exploratory Drilling at Elk Hills," Max Eastman, U. S. Navy Department, and Cmdr. F. L. Ruhlman, USN, Elk Hills Naval Reserve, Calif.; "The Limits of Uncertainty of Permeability Averages," Jan Law, consulting engineer, Los Angeles.

FRIDAY, OCTOBER 24

9:30 a.m.—"Discussion of Some Electric-Log Interpretation Problems," R. D. Ford and M. E. Loy, Schlumberger Well Surveying Corp., Bakersfield, Calif.; "Planning a Multiple-Well Directional-Drilling Program for Offshore Locations," Gordon Jackson, vice president and general manager and J. B. Murdoch, Jr., chief survey engineer, Eastman Oil Well Survey Co., Denver; "Mechanics of Wave Action on Structures," Walter H. Munk, Scripps Institution of Oceanography, La Jolla, Calif.

1:30 p.m.—"A Spinner-Type Subsurface Flow Indicator and Some of Its Practical Field Applications," Charles M. Bryant, Dowell Incorporated, Tulsa; "Stresses About the Bore Hole of a Deep Well," A. J. Miles, professor of mechanical engineering, Missouri School of Mines and Metallurgy, Rolla; "California Oil Outlook," R. L. Minckler, vice president, General Petroleum Corp., Los Angeles.

New Instrument Society Section Plans Meeting

The newly formed Oklahoma section of the Instrument Society of America has scheduled for September 29 in Tulsa its first meeting since receiving its charter from the national organization.

The group was organized in Tulsa during the latter part of August and has become the thirty-fourth section of the national society. The date of the coming meeting is the deadline for charter - membership applications. C. R. Horton, of Macnick Co., is in charge of arrangements for the meeting September 29.

PERSONALS

L. G. Smith Elected Creole Vice President

THE election of L. G. Smith as a vice president has been announced by Creole Petroleum Corp., an affiliate of Standard Oil Co. (N.J.). He will assume charge of all the operations of Creole's refining activities.

Smith has been active in the petroleum industry since 1913. He was appointed general manager of the Lago Oil & Transport Co., Ltd., Aruba refinery in 1933 and was elected president of that company in 1944. He remained in Aruba until September 1946, when he came to New York to accept a position in the foreign refining department of the Standard Oil Co. (N.J.).

Smith was graduated from the University of Illinois in 1913 with a B.S. in mechanical engineering and is a member of Tau Beta Pi, honorary engineering fraternity. He was decorated by Queen Wilhelmina in 1936 for distinguished service to the Netherlands Government with appointment as Officer and again in 1946 as Knight Commander of the Order of Orange-Nassau.

At the resent time, Smith is in Venezuela on an inspection tour. On his return to New York he will assume his new duties in the offices of Creole Petroleum Corp. in the Empire State Building.

Laurence C. Bergquist, Navy reserve lieutenant commander and a member of the foreign marketing staff of Standard Vacuum Oil Co. since 1928, has been awarded the Legion of Merit and authorized to wear the Combat V decoration for "exceptionally meritorious conduct" in the Gilberts - Marshalls area in 1944-45. Bergquist is assistant to the area manager in New York for Standard Vacuum's southwest Asia and Philippines divisions.

H. Hugh Willis, specialist in electronics, has been appointed director of research and development of Kellex Corp., subsidiary of M. W. Kellogg Co. dealing with atomic-energy development.

Wayne Dean, formerly drilling superintendent for California Co., Rangely, Colo., has joined Kerr-McGee Industries, Inc., as Rocky Mountain superintendent, headquarters, Casper, Wyo. Other changes in Kerr-McGee Industries, Inc., include **F. H. Allen,** who resigned as superintendent, Rangely field, to accept a position as superintendent for Powers Drilling Co., Casper, Wyo., and the appointment of **Charles Miller,** formerly with Loffland Brothers in Venezuela, to succeed Allen.

Charles L. Lockett, former pipeline executive with Standard Oil Co. (N.J.), who is slated to head the projected Middle East Pipe Lines, Ltd., is now in London on a business trip. The new Middle East company will be owned by Anglo-Iranian Oil Co., Ltd. Jersey Standard and Socony-Vacuum Oil Co., Inc.

Roger van den Perre, United States representative for Cie. Francaise des Petroles, is in France on business where he plans to remain until late October.

E. R. Douglas, graduate geologist from Texas Christian University, has joined Atlantic Refining Co.'s geological staff at Midland, Tex., under **Niles D. Winter,** district geologist.

R. W. Miller, in charge of export sales of crude oil and products and coordinator for purchases and exchanges for Creole Petroleum Corp., has been elected a vice president. Miller has been associated with other Standard Oil Co. (N.J.) interests since 1919 when he joined the Bayway refinery.

Joseph P. Walsh, formerly assistant to Sinclair Oil Corp.'s general counsel, has been elected general counsel succeeding **P. C. Spencer** who recently became president of Sinclair Refining Co.

George R. Wesley, district geologist for Skelly Oil Co. at Evansville, Ind., has been transferred to Tulsa headquarters. **Ben Ploch** will succeed Wesley.

EDITOR LEAVES FOR SOUTH AMERICA

Here Dr. Oscar B. Irizarry, editor of Petroleo Interamericano, Latin American affiliate of The Oil and Gas Journal, receives the good wishes of W. G. Skelly, president of the International Petroleum Exposition, before his departure this week on a 20,000 - mile, 3 - month tour of 12 South and Central American countries. In addition to his editorial work in connection with his publication, Irizarry will serve as official representative and ambassador-at-large for the exposition next May 15-22 in Tulsa, carrying invitations to oil-industry and government officials on behalf of Skelly and Roy J. Turner, Oklahoma governor

Clarence J. Priegel is now associated with **Harry H. Nowlan,** consulting engineer, Evansville, Ind. Priegel is a valuation engineer on Nowlan's staff.

Dale Parker of Mount Vernon, Ill., has been made superintendent for the Keating Drilling Co. in Illinois basin area.

L. B. Denning, Jr., Lone Star Gas Co., has been made operating manager for the general division of distribution. **Wesley F. Wright** was named general manager of the Dallas division of distribution. **Thomas J. Skrabanek** was made assistant superintendent of compressor stations, assisting **B. L. Rogers,** superintendent. **W. P. Stone** was named assistant manager of the industrial and commercial gas department of the general division, and **John F. Moore** was appointed manager of the industrial department for the Dallas division.

S. Miller Williams, Jr., president of Williams Brothers Corp., will sail from New York to England October 3. From there he will fly to Beirut, Lebanon, where he will spend several weeks in connection with the affairs of Williams Brothers Overseas Co. Williams will return to the United States early in November.

Howard A. Cowden, secretary of the International Cooperative Petroleum Association and president and general manager of Consumers Cooperative Association, Kansas City, Mo., is en route to London to attend the first meeting of directors of the world oil cooperative September 25-26.

J. G. Frye has been named district manager for Shell Chemical Corp. with headquarters in Chicago. He was associated with Carbide & Carbon Chemicals Corp. before joining Shell last year.

Charles E. Moser, of the research administration staff of the Beacon laboratories of The Texas Co., has been transferred to a temporary assignment at Port Arthur, Tex. Other transfers include: **W. J. Coppoc,** from Port Arthur to the Beacon laboratories, grease research department; **Max Herbst,** from the Beacon laboratories to Lawrenceville, Ill., products-application department. **Gordon Peattie** and **Henry C. Brown,** chemist in the Beacon laboratories, are on educational leave from The Texas Co.

George F. Polzer, Jr., former chemist in the Beacon laboratories, has been transferred from the technical and research division of The Texas Co. in New York to the purchasing department as a technical consultant.

Joseph K. Roberts, general manager of research for Standard Oil Co. (Ind.), has been elected a member of the board of directors to succeed **H. E. Hanson** who has retired as a member of the board and also as general manager of sales. Roberts is a former chairman of the petroleum division of the American Chemical Society and is now a director of the American Institute of Chemical Engineers. **R. F. Baity,** assistant general manager of general sales, will succeed Hanson in the sales position

Eugene A. Wurster has been appointed assistant comptroller of Socony-Vacuum Oil Co., Inc. He succeeds **Riche H. Johnson,** who retired recently after 40 years of service.

Orville Harden and **John R. Suman,** both vice presidents and directors of Standard Oil Co. (N.J.), and **Harold F. Sheets,** board chairman of Socony-Vacuum Oil Co., Inc., have been named to board of directors of Arabian American Oil Co.

John H. McKenzie, fire and safety inspector at the General Petroleum Corp.'s Torrance (Calif.) refinery, has been appointed manager of the safety department.

Harold D. Allen and **Carl M. Marberg** have been appointed research associates on the staff of Standard Oil Co. (Ind.). They will assist **W. H. Bahkle,** associate director of research, in connection with the company's long-range program of research in the field of chemicals from petroleum. Dr. Allen comes from Colgate-Palmolive-Peet Co., where he has had charge of pilot-plant and process-design work in the division of development engineering. Dr. Marberg has been chairman of the organic-chemistry research section of the Midwest Research Institute.

B. W. Pickard, former manager of the marketing department's gasoline and fuel-oil division of Standard Oil Co. of California, has been named assistant to the vice president. Pickard has had 25 years of continuous service with the company. **L. W. Aubry,** assistant manager of the aviation division of Standard of California, will succeed Pickard as manager of the gasoline and fuel-oil division. **J. H. Osmer** has been named secretary of California Research Corp., a Standard of California subsidiary. He succeeds **O. S. Loud** who will now devote full time to his duties as coordinator of patents and infringement.

James R. Shipley, Jr., has been named chief engineer of Sohio Pipe Line Co. and of the transportation department of Sohio Petroleum Co., both subsidiaries of Standard Oil Co. (Ohio). **Joseph D. Harnett** was made general superintendent of the same two companies and **Charles B. Lester** was named head of the new research and development section to assist Shipley. All three men will keep their offices in St. Louis. Shipley, a graduate of the University of Kansas in 1939, joined Sohio in 1940 as an engineer in the transportation department and was transferred to St. Louis when the department set up an operating office there. Shipley and Harnett will assist **E. F. Morrill,** vice president of Sohio Pipe Line Co., who also is assistant manager of the transportation department of Ohio Standard and manager of the transportation department of Sohio Petroleum. Harnett, a graduate of Purdue University in 1935, served with Consolidated Edison Co., New York, and Worthington Pump & Machinery Co. before he joined Sohio in 1941. Lester, a graduate of Purdue University, joined the Sohio as a junior engineer in the research division of the manufacturing department.

J. R. SHIPLEY, JR.

J. D. HARNETT

C. B. LESTER

John K. Evans, Washington representative for Asiatic Petroleum Corp., left the United States September 8 on a 2-month business trip to Tokyo, Shanghai, Manila, and London.

W. E. Scott has been named head of the stores department in the Kansas City offices of Panhandle Eastern Pipe Line Co. He succeeds **J. S. Stevenson** who was named superintendent of transmission pressure control in Kansas City. Another promotion of Panhandle Eastern is **Hugh W. Gillian,** former regulatorman at Paola, Kans., who has been assigned the meter engineer's job at Mexico, Mo.

PERSONALS

R. L. Johnson, superintendent of the Sunray Oil Corp. refinery at Santa Maria, Calif., has been transferred to the company's new refinery at Beckett, Okla., near Duncan where he will be superintendent. Johnson has been special assistant to Vice President **F. L. Martin,** who is in charge of the refining division, in expediting a remodeling and expansion program now under way at Beckett. Johnson built the original Oil States refinery at Allen, Okla., in 1921, and was superintendent there when Sunray bought the property in 1929. Two other changes in the Santa Maria refinery are: **K. D. Ford,** who becomes the new superintendent and will be in charge of crude-oil purchases, pipe-line and refining operations; and **Harry F. Arnold,** refinery sales manager, who has been appointed office, sales, and credit manager.

R. L. JOHNSON

K. D. FORD

C. T. Porter has been placed in charge of the new office opened at Alice, Tex., by Coast Oil Corp.

C. A. Hamman, petroleum engineer for Pure Oil Co. in the Fort Worth office, has been transferred to Olney, Ill., as division petroleum engineer. **Paschal Martin,** former division petroleum engineer at Olney, will take over Hamman's duties in an exchange of positions.

A. F. Boudreau, Jr., formerly manager of the Texas division of Manhattan Construction Co., has been been named executive vice president of Three Rivers refinery at Three Rivers, Tex., and Petroleum Trading & Transport Co., Tulsa. He will supervise a new expansion program at the refinery.

Dr. L. R. Laudon, of the University of Kansas, with eight graduate students of the university, has returned home after spending 8 weeks in geological work in the Wapiti Lake area in northwestern Alberta and northeastern British Columbia.

Robert I. Brougham, former assistant treasurer of Standard-Vacuum Oil Co., and former treasurer of Creole Petroleum Corp., and recent foreign-exchange manager of Standard Oil Co. (N.J.), has been elected financial vice president of Arabian American Oil Co. **E. G. Collado,** former United States executive director of the International Bank for Reconstruction and Development, will succeed Brougham as foreign-exchange manager.

Arne Junger, who has been working out of Calgary, Alta., as senior seismographer for Shell Oil Co., Inc., has been transferred to the southern Rocky Mountain area.

J. C. Whitney, vice president, Eastern States Petroleum Co., Inc., is resigning September 30, it has been reported. He plans to enter a business outside of the oil industry, in Tacoma, Wash.

Shifts

Dean H. Landis, engineer, General Petroleum Corp. of California, Bakersfield to Taft, Calif.; **H. D. Campbell,** engineer, Union Oil Co. of California, Los Angeles to Whittier, Calif.; **R. E. Schmidt,** engineer, Drilling & Exploration Co., Ventura, Calif., to Salt Lake City, Utah; **T. H. Sandoz,** engineer, Pan American Production Co., Aspermont to Abilene, Tex.; **H. L. Hoover,** foreman, The Texas Co., Cuero to Port Arthur, Tex.

Gordon G. Lancaster, engineer, Sun Oil Co., Premont to Odessa, Tex.; **C. H. Thurber,** engineer, Plymouth Oil Co., San Angelo to Sinton, Tex.; **M. J. Millet,** foreman, The Texas Co., Hammond, La., to Hattiesburg, Miss.; **T. S. Green,** foreman, Republic Exploration Co., Jonesville to Bunkie, La.; **L. D. Griffin,** superintendent, N. H. Wheless Drilling Co., Houma to Haynesville, La.; **E. J. Bruce,** superintendent, N. H. Wheless Drilling Co., Vivian, La., to Lewisville, Ark.

Robert J. Moffatt, geologist, Carter Oil Co., Shreveport to Rawlins, Wyo.; **T. L. Metcalf,** engineer, Ryford Oil Co., McLeansboro to Mount Vernon, Ill.; **C. R. Temple,** engineer, The Texas Co., McLeansboro, Ill., to Tulsa; **Paschal Martin,** engineer, Pure Oil Co., Olney, Ill., to Gilmer, Tex.; **Pat E. Fletcher,** superintendent, Atlantic Refining Co., Great Bend, Kans., to Odessa, Tex.; **E. H. Winesburg,** superintendent, Barnsdall Oil Co., Oxford to Burrton, Kans.

Kermit D. Hutchins, engineer, Magnolia Petroleum Co., Powell to Worland, Wyo.; **Jack E. Clark,** superintendent, Noble Drilling Corp., Riverton, Wyo., to Rangely, Colo.; **Richard A. Aukerman,** engineer, Shell Oil Co., Inc., Elk City, Okla., to Oklahoma City; **N. Bruce Calder,** engineer, Magnolia Petroleum Co., Chickasha, Okla., to Austin, Tex.; **H. V. Copeland, Jr.** geologist, Magnolia Petroleum Co., Woodward, Okla., to Cuba, N. M.

Charles H. Hesser, engineer, Stanolind Oil & Gas Co., Wewoka, to Oklahoma City; **Bob Leibrock,** engineer, Stanolind Oil & Gas Co., DeWitt, Ark., to Tulsa; **A. D. Wesley,** engineer, Plantation Pipe Line Co., La Grange, Ga., to Flat Rock, Ill.; **James Helis,** engineer, Atlantic Refining Co., New York to Philadelphia; **B. B. Bradish,** geologist, Skelly Oil Co., Walsenburg to Fort Collins, Colo.; **J. R. Gilliland,** foreman, General Geophysical Co., Benkelman to Sidney, Nebr.

DEATHS

James Edwin McClure, 67, retired oil-field supply manufacturer, died September 9 in Charleston, W. Va.

Cyril N. Poling, 47, president of Poling Oil Co., died September 9 in Westfield, N. J.

John D. Walther, 46, mechanical engineer with Standard Oil Development Co., died September 8 in Westfield, N. J.

Roy A. Douglas, 45, superintendent of the T & C Drilling Co., Midland, was killed September 1 in an automobile accident near Brownfield, Tex.

John M. Kennerly, an accountant with The Texas Co., died September 5 in Houston. He joined The Texas Co. in 1915.

Thomas J. O'Reilly, 76, formerly with El Aguila Oil Co., Corona Oil Co., and Huasteca Petroleum Co., died September 5 in Brownsville, Tex.

James E. Goodwin, 57, of Barlow & Woodworth, oil operators in the Arvin, Calif., area, died September 7 in Bakersfield, Calif.

Richard P. Swinsky, 48, former vice president of the Gulf Publishing Co., died September 13 in Houston.

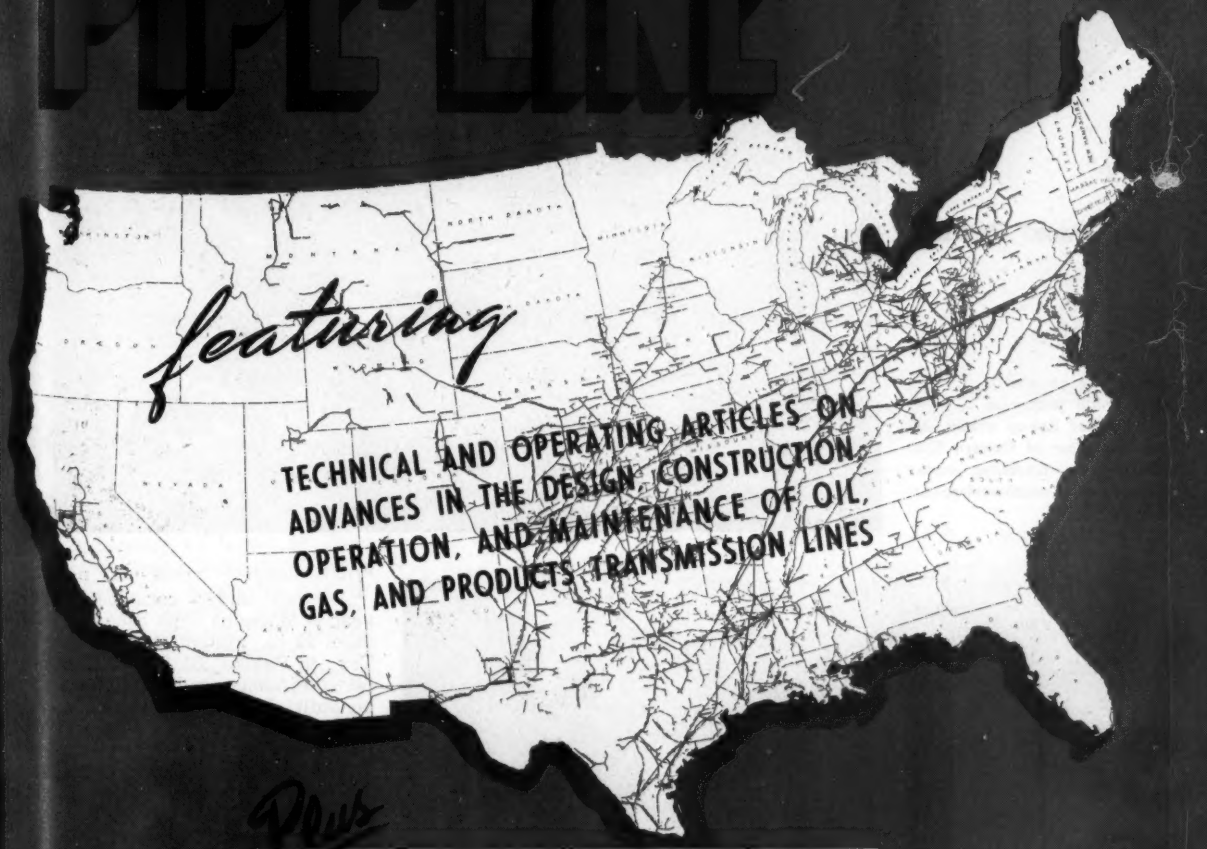
E. S. Dustin, 63, independent oil operator of Wichita, died September 12 in Wichita.

L. L. Donnell, 66, Texas oil operator and identified with the Burkburnett oil development, died September 10 in Alamogordo, N. M.

Peter E. Fluor, 52, president and chairman of the board of Fluor Corp., Ltd., died September 10 in Anaheim, Calif.

THE OIL AND GAS JOURNAL'S

Annual PIPE-LINE *Number*



featuring

TECHNICAL AND OPERATING ARTICLES ON ADVANCES IN THE DESIGN, CONSTRUCTION, OPERATION, AND MAINTENANCE OF OIL, GAS, AND PRODUCTS TRANSMISSION LINES

Plus

A 36-BY-48-IN. MULTICOLOR INSERT MAP OF THE PRINCIPAL TRUNK LINES IN OPERATION, UNDER CONSTRUCTION, AND AUTHORIZED, FOR THE TRANSPORTATION OF NATURAL GAS

Magnolia's 20 in. CRUDE-OIL LINE

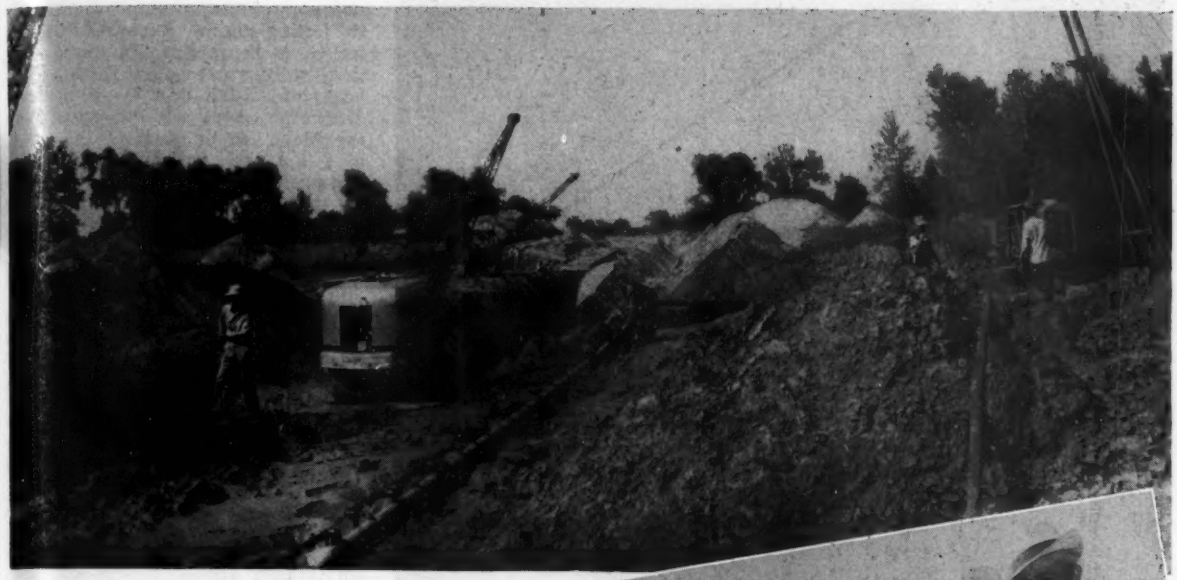
by Paul Reed

Right: Pipe gang of H. C. Price Co. spread preparing to operate internal line-up clamp. Below: Dragline of Eastern Construction Co. trenching across Little River in southwestern Arkansas

THE longest crude-oil pipe-line system under construction this year is Magnolia Pipe Line Co.'s 647-mile 20-in. system from Corsicana, Tex., to Patoka, Ill. This is the longest continuous crude-oil pipe line to be built since the big-inch line was constructed to meet the war emergency.

Methods applied in building this line exemplify advanced modern practices for large-scale big-inch pipe construction. Furthermore, it will be the first postwar line from the Southwest to be built into the Salem area of southern Illinois to serve rising demands of the Middle West.

This project originates at the hub of Magnolia's existing network of pipe lines at the Corsicana terminal, from which the company will ship large batches of sweet and sour crude to the delivery terminal at Patoka, for transshipment through Magnolia Pipe Line Co.'s 10-in. system. Provision is to be made later for shipping through other carriers to the Chicago area.

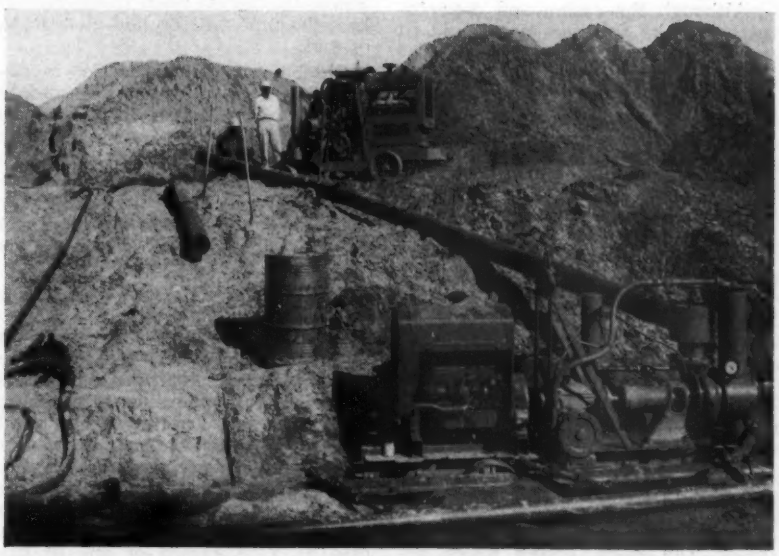


Above: Red River crossing: Three drag lines digging trench being dewatered by well-point method; pump unit (right) for jetting down well points is being moved to a new position. Right: George T. Jackson, construction superintendent, W. T. Manness, chief inspector, Red River crossing, W. W. Walker, welding inspector, Magnolia Pipe Line Co.; Chief McCoy, spread superintendent, Oklahoma Contracting Co.; Paul Reed, pipeline editor, The Oil and Gas Journal; J. E. McGeath, assistant general superintendent, Magnolia Pipe Line Co., at Red River crossing

This article presents information regarding methods for laying pipe for this 20-in. line which was procured by the author on a 2-day field trip with J. E. McGeath, assistant general superintendent, through arrangements made by Lester H. True, vice president and manager, Magnolia Pipe Line Co. During the trip, by plane and car, McGeath was accompanied at different times by George T. Jackson, superintendent of construction, and O. T. Norwell, material man.

Perhaps the most unusual feature of this project is the manner in which some of the major river crossings are constructed. To exemplify this, the procedure being followed at the Red River crossing will be described. The annular space between the 24-in. casing and the 20-in. pipe line is filled with low-melting-point (45 F°.) roofing pitch to which is added a flux to permanently stiffen the material after it has cooled in the annular space. One barrel of flux is mixed with 8 bbl. of dope.

The crossing is being laid by the well-point system of dewatering. In this way, a dry trench is being dug in the sand across the entire width of the river. In the course of the operation, the stream of the river is diverted so as to flow over a section



Well-point jet-pump installation, at sump above dewatering pump, supervised by A. J. Salley, Moretrench Corp., at Red River crossing being laid by Oklahoma Contracting Co.

Top: Dope operations for applying coating and wrapping. Above: Immediately after doping, seen a short distance ahead, the pipe is lowered in the ditch and completely backfilled

of the pipe, already laid, while the remainder of the pipe is being laid across the river.

Although the casing and dope together make the line more rigid, it is, nevertheless, possible to lay 5,000 ft. across the Red River with an upstream bow as much as 500 ft. Experience of the Magnolia company has demonstrated that pipe laid with a sufficient upstream bow across the river has not washed out during flood conditions.

The well-point system not only provides a more economical river-crossing job, but it also affords valuable advantages which come with having an opportunity to lay all of the pipe in a dry trench. This enables inspectors to ascertain continually the condition of pipe as each section is laid in the ditch and welded to the part of the line which has been previously installed.

The pipe line is being laid across the Red River in 500-ft. sections. The 20-in. ½-in.-wall-thickness pipe is welded with five beads and a stripper bead. The 24-in. casing welds are reinforced with weld wraps. No river clamps are used.

On the north side of the river the trench is dug to a depth of 14 ft., while on the south side it is 10 ft. Below the lowest point in the stream bed, the pipe will be laid at a depth of 6 ft.

Oklahoma Contracting Co. is dewatering with well points along only one side of the trench. By this means it is possible to do a satisfactory job of dewatering to a depth of 18 ft. with well points 24 ft. long. If dewatering were done to a greater depth, it would be necessary to have a second line of well points on the other side of the trench.

Twenty-four-foot well points are installed on 5-ft. centers. At 300-ft. intervals a pump is installed, pulling a 25-in. vacuum. At the time the author visited the project, these pumping units were each pumping 1,000 gal. per minute. The rated capacity of each unit is 1,200 gal. By operating at 75 per cent capacity the entire dewatering operation can be handled more smoothly since there is available excess capacity to use in case of a shutdown of one of the pumping units. Self-jetting well points are installed at the rate of one per minute with the use of 135-lb. jetting pumps. Excavating of the trench is being done by three drag lines: a Byers ¾-yd., a Buckeye ¾-yd., and a Link-Belt ½-yd.-speeder.

Several rivers will be crossed by the Magnolia line where the 20-in. pipe is to be cased with 24-in. pipe and protected with dope in the annular space. These rivers are the Trinity, Sabine, Ouachita, Sulphur, Cossatot, St. Francis, Maumelle, and Little Mary's.

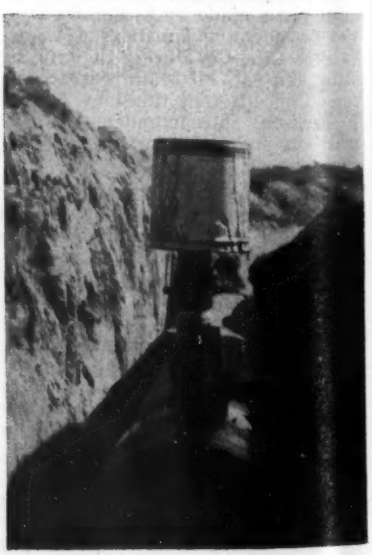
Cased River Crossings

Prior to building the 20-in. project, Magnolia has had successful experience in laying cased lines with dope protection for crude-oil lines across Navasota, Trinity, and San Jacinto rivers; for the butane line across Nueces River; and for the Oklahoma gasoline line across Canadian River.

In addition to the Red River crossing job, Oklahoma Contracting Co. has main-line contracts on this project totaling approximately 423 miles in three sections. Section 1, extending 108 miles northeast from Corsicana station, was completed over favorable prairie country in the fast time of 75 elapsed days or approximately 1½ miles per day. On completion, the main-line spread moved to Patoka to lay 315 miles at the north end of Sections 4, 5, and 6.

Section 3, contracted by H. C. Price Co., is in the rugged wooded hills of central Arkansas between Little Rock and Hot Springs. Section 2, in southwest Arkansas, is contracted by Eastern Construction Co.

Magnolia chief inspectors are as follows: Section 1, A. D. L. (Dot) Price; Section 2, L. R. Jackson; Section 3, Max Lowry; Section 4, H. B. (Tex) Jones; and the Red River crossing, William T. Maness. A. D.



Connections for injecting pitch in annular space between 20-in. pipe and 24-in. casing, closed by sealing gasket

Pike is chief inspector for the entire project.

The rate of progress of main-line construction, from the beginning of pipe laying on June 2 to final completion scheduled for February 1948, will be determined by pipe deliveries.

Terrain traversed by the project is characterized by fairly open country in the areas at both ends. In between there is much dense forest through which work must be pushed during good weather to avoid harder going in rainy months. Some of the elevations along the route are as follows: Corsicana, 418 ft.; Cockspur Trail, Ark., 850 ft. (the highest point on the line); Doniphan, Mo., 570 ft.; and Patoka, 504 ft.

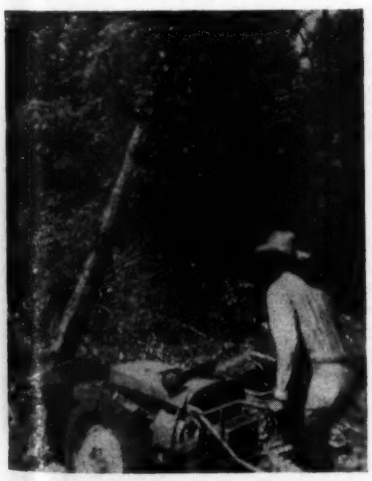
Radio and Airplanes

Characteristic of progressive 1947 practices is the extent to which two-way radio communication has been adopted by two of the contractors on the line in order to facilitate exchange of information between supervisors driving cars through talking to each other and the field office. Contractors' executives use airplanes owned by their firms for contacting their operations. The Magnolia company operates its own plane out of the Little Rock airport.

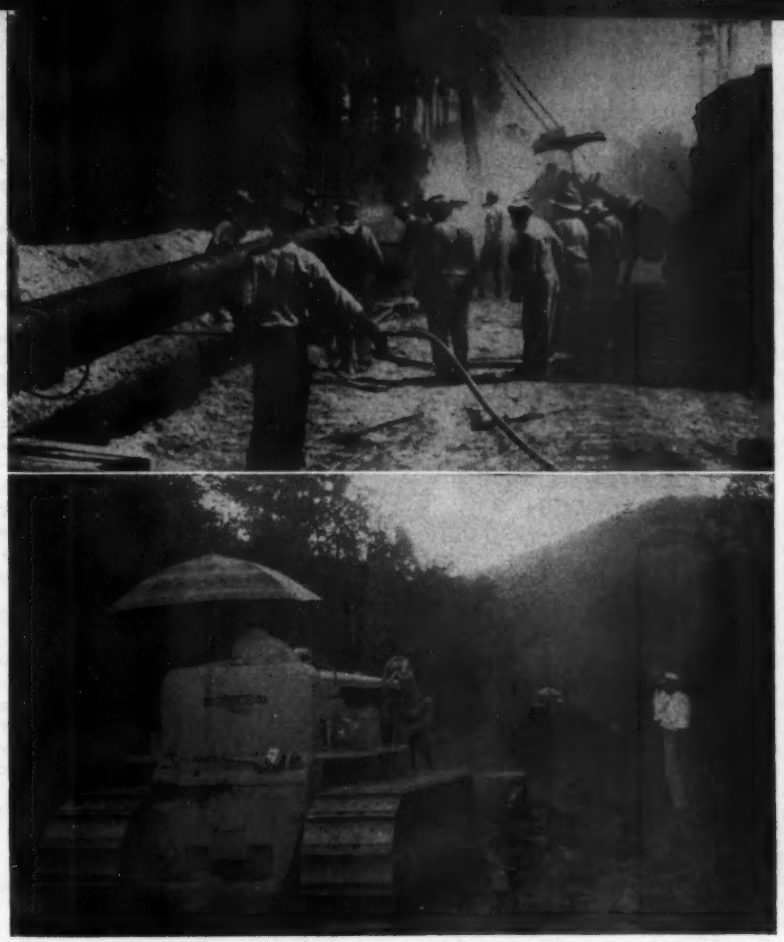
Although some of the brush gangs started cutting timber for the project almost entirely with hand saws, the use of power saws of both the disk and jack-chain type has increased rapidly until now there are approximately 15 units of such equipment operating in advance of the various spreads.

For digging the 40-by-40-in. ditch, the largest-size ditching machines are used. In some cases, two-stage ditching is done by having a smaller ditcher precede the larger one to cut a 12-in. wide pilot ditch.

Most of the pipe is of 5/16-in. wall thickness with tensile strength of 75,000 lb. In certain locations, ½-in. wall pipe is used, such as river crossings and low ground subject to prolonged inundation. At a 5-mile section on the discharge side of each pump station, ½-in. wall pipe is also used. Pipe for the project is being supplied by Youngstown Sheet & Tube Co. and National Tube Co. Pipe is bent by the cold method using C.R.C. power-driven machines.



Cutting timber by power-driven saw of Eastern Construction Co. brush gang



Top: Bottom of waterworks enamel coating, wrapped with glass mat, being cooled by water spraying from perforated semicircular pipe. Above: Clearing right-of-way near Cockspur Trail, Ark., with bulldozers and rooter of the H. C. Price Co. spread

Welding Operations

Welding is done with Fleetweld No. 5 electrodes in the following manner: ⅛-in. or 5/32-in. for stringer beads and 3/16-in. for the topping-off bead. There have been no welding difficulties on the job. Each spread has approximately 14 welders, 2 tack welders, 2 utility welders, and 10 bell-hole welders. Line up is done with internal clamps.

The entire line is coated with coal-tar waterworks enamel wrapped with glass mat. All spreads have C.R.C. dope machines which are supplied by the new-type C.R.C. tar pots equipped with thermostat control and power-driven agitator.

In sandy soil the only wrapping applied is glass mat. Where the soil is tight, poorly drained, or otherwise corrosive, an asbestos felt wrapper is applied over the glass mat. Reilly tar, Bitumastic, and Barrett dope is used; this is wrapped with Fiberglas. Felt is Rubberoid, Johns-Manville, and Phillips Carey.

From the dope machine, the pipe drops immediately into the ditch and is backfilled only a few hundred feet to the rear. This is an unusual practice in laying such large-diameter pipe. Magnolia applied this method in laying the Midland-Corsicana loops in recent years. On level ground a slack loop is left every 700 ft. which is to be lowered early in the morning following doping.

The holiday detector for the project is carried in the chief inspector's car for spot checking where he thinks that pipe protection should be tested. Pipe laid for the main line is tested by water pressure of 800 psi. in sections of 70 miles in length. Pipe at river crossings is tested by air pressure after it has been welded in sections.

Methods applied in laying pipe for the Corsicana-Patoka project have been developed as the result of close study given by Magnolia to the problems of economical construction for long service with a minimum maintenance expense in future years.

BENJAMIN MILLER, whose three-part article on "Pipe Line Flow Forumlas" starts in this issue, has been engaged in independent consulting practice a little more than 2 years. Previously he was at the Institute of Gas Technology in Chicago, as chairman of the division of education and basic research. Before that, Miller had spent 16 years in the Henry L. Doherty-Cities Service Co. organization, serving as assistant to the chief technologist and later as consulting engineer and assistant to the president of Gas Advisers, Inc. In these capacities he worked on a wide variety of technical and economic problems in the fields of oil and gas production, transportation, refining, and marketing, being concerned chiefly with new developments.

Miller was graduated from Columbia College in 1924, did his graduate work at Columbia University's School of Engineering, and received the degree of chemical engineering in 1926.

Mentionable consulting work includes cost allocation studies made for Mississippi River Fuel Corp. in connection with a Federal Power Commission rate case (see "Watching Washington," The Oil and Gas Journal, page 72, August 16, 1947), and services rendered to Southern California Gas Co. and Southern Counties Gas Co. of California in connection with the manufacture, inspection, and testing of the 30-in. pipe for the California section of the Texas-Los Angeles line. The latter included recommending a quality-control system which required internal hydrostatic testing of specimens prepared from full joint samples to determine the effective yield pressure and the rupture pressure. The accompanying photograph shows Miller examining the break in a test specimen.

Pipe-Line Flow Formulas

by Benjamin Miller

IN order that any fluid, be it crude oil or gasoline, water, gas, or air, flow through a pipe line there must be a pressure on the fluid which decreases with distance along the line in the flow direction, unless the flow is from a higher to a lower elevation, in which case the difference in elevation is equivalent to a difference in pressure.

Oil and gas lines operate for the most part by virtue of pressure differences created by pumps and compressors. In water-supply systems the flow is commonly due to gravity. Since the art of hydraulics had been developed before pipe-line transportation of oil and gas became significant, it is not surprising that pipe-line design continues to make use of forms and concepts enunciated by the hydraulicians who worked in the period of a hundred years, more or less, which included the American Revolution and the Franco-Prussian War. In particular, we sometimes still express the relation between the flow velocity, the size of the pipe, and the change in pressure or elevation along the pipe by the Darcy-Weisbach formula introduced in the middle of the nineteenth century, or, less frequently, by the Chezy formula announced in the last third of the eighteenth century.

The Darcy-Weisbach formula may be written:

$$h_f = f L V^2/2 g D \qquad (1)$$

where

h_f = loss of head due to friction, in feet of the flowing fluid,
L = length of the pipe, in feet,
V = the flow velocity in feet per second,
g = the acceleration of gravity, in feet per second squared,
D = the pipe diameter, in feet, and
f = the friction factor, a dimensionless number to be determined by experiment.

The flow velocity V is the velocity of the fluid averaged over a cross-section perpendicular to the pipe axis, and is defined by:

$$V = 4 Q/\pi D^2 \qquad (2)$$

where

Q = fluid flow rate in cubic feet per second.

The Chezy formula, explicit for the flow velocity is:

$$V = C (h_f D/4 L)^{0.5} \qquad (3)$$

where

C = the Chezy discharge coefficient, a number (not dimensionless) to be determined by experiment.

Comparison of Formulas 1 and 2 shows that the friction factor f and the Chezy discharge coefficient C are related by:

$$C = (8 g/f)^{0.5} \qquad (4)$$

The friction factor has become more

widely known and used than the Chezy discharge coefficient C. Since f is dimensionless and C is not, this is a fortunate development. However, it is convenient to have a formula explicit for the flow velocity, so we introduce a dimensionless flow coefficient, C_f, related to the friction factor f by:

$$C_f = (1/f)^{0.5} \qquad (5)$$

While flow may be caused by the force of gravity acting through a difference in elevation, the flow mechanism, including the frictional drag of the pipe wall and the fluid on each other, is entirely independent of gravity. For this reason it is legitimate to facilitate computations by assuming that the pipe is horizontal, making adjustments in particular cases where there is a change in elevation. On the horizontal pipe assumption Formula 1 can be modified so that the loss of head due to friction is replaced by the difference in pressure between the beginning and the end of the pipe, the right-hand side being simultaneously multiplied by the specific weight of the fluid, the new formula being:

$$P_b - P_e = f L V^2 \gamma / 2 g D \qquad (6)$$

where

P = pressure, in pounds-force per square foot,

P_b = pressure at the beginning of the pipe,

P_e = pressure at the end of the pipe, and

γ = specific weight of the fluid, in pounds-force per foot-to-the-third power.

To avoid even the suggestion that gravity has an influence, the density of the fluid may be introduced, eliminating specific weight and the acceleration of gravity, so that the formula becomes:

$$P_b - P_e = f L V^2 \rho / 2 D \qquad (7)$$

where

ρ = density of the fluid, in pound-force seconds squared per foot-to-the-fourth power.

If the fluid is compressible it is necessary to use a proper average value for ρ, or we may write the formula for a differential length dL, making it applicable to all fluids, as:

$$-(dP/dL) = f V^2 \rho / 2 D \qquad (8)$$

where

(dP/dL) = the positive pressure gradient, or the rate of increase in pressure with distance from the beginning of the pipe, in pounds-force per foot-to-the-third power

Formula 8 can be rewritten in a form similar to the Chezy formula, but with the dimensionless flow coefficient C_f:

$$V = C_f [-2 D (dP/dL)/\rho]^{0.5} \qquad (9)$$

Viscosity and the Reynolds Number

These rearrangements of the antique formulas are prelude to our discussion of the advances of the last hundred years. Outstanding among these advances was the quantitative analysis of the part played by the fluid viscosity in the mechanism of pipe friction. This led to the discovery that the friction factor is determined by the viscosity and density of the fluid, the pipe diameter, the flow rate, and the detailed geometry of the pipe-fluid interface; the last-mentioned item is sometimes referred to as the roughness or smoothness of the pipe's inside surface. In particular, it has been found that the value of f (and likewise of C_f) is a function of a parameter called the Reynolds number defined by:

$$N_R = D V \rho / \mu \qquad (10)$$

where

N_R = the Reynolds number, a dimensionless number, and

μ = the viscosity of the fluid, in pound-force seconds per square foot.

The relationship may be expressed as:

$$f = 1/C_f^2 = \phi (N_R) \qquad (11)$$

where

ϕ = function of.

Formula 11 means that for a particular pipe the value of f is fixed by the value of N_R, so that if we pass through the pipe first one fluid, then another having different viscosity or density, the friction factors can be made the same for the two fluids by adjusting the flow velocities to make N_R the same in the two cases, provided neither fluid reacts chemically with the material of which the pipe is made. For example, a typical density for natural gas at atmospheric pressure and temperature is 1.4×10^{-3} lb.-force sec.^{2}/ft.^{4} and a typical viscosity is 2.1×10^{-7} lb.-force sec./ft.^{2} If such gas moved through a pipe having an inside diameter of 1.62 ft. with a flow velocity of 92.6 ft./sec., the value of the Reynolds number would be, by Formula 10:

$$N_R = \frac{1.62 \times 92.6 \times 1.4 \times 10^{-3}}{2.1 \times 10^{-7}} = 10^6$$

and there would be a definite value of the friction factor. Now if through the same pipe there were moved gasoline having a density of 1.4 lb.-force sec.^{2}/ft.^{4} and a viscosity of 8.4×10^{-6} lb.-force sec./ft.^{2}, with a flow velocity of 3.7 ft./sec., the Reynolds number would be:

$$N_R = \frac{1.62 \times 3.7 \times 1.4}{8.4 \times 10^{-6}} = 10^5$$

and the friction factor would be the same as it was for the natural gas moving at a velocity of 92.6 ft./sec.

Smooth and Rough Pipe

The friction factor at a Reynolds number of 10^6 for one pipe having a diameter of 1.62 ft. may or may not be the same as the friction factor at the same Reynolds number for another pipe having the same diameter. However, there is a minimum value of the friction factor at a Reynolds number of 10^6, and a corresponding maximum value of the flow coefficient, for a pipe having a diameter of 1.62 ft.; this maximum value of the flow coefficient is 9.27, and the corresponding value of the friction factor is 0.0116. The minimum value of the friction factor at any Reynolds number is independent of the size of the pipe; that is, the minimum friction factor at the Reynolds number of 10^5 is 0.0116 for pipe having a diameter of 0.01 ft., for pipe having a diameter of 10 ft., and for pipe having any other diameter.

Pipe which exhibits the minimum friction factor is said to be smooth pipe; pipe which exhibits a friction factor higher than the minimum is said to be rough pipe. Whether a pipe is rough or smooth in the flow sense depends upon the Reynolds number. A pipe may be smooth at one Reynolds number, and rough at a higher Reynolds number. The indications are, though conclusive proof is lacking, that every pipe is smooth at all Reynolds numbers less than a particular Reynolds number characteristic of its surface, and rough at all higher Reynolds numbers.

If a pipe is smooth, therefore, the value of the friction factor is dependent only upon the Reynolds number of the flow, and thus is fixed and determined as soon as the Reynolds number is known. On the other hand, if the pipe is not smooth, all that can be learned about the friction factor from the Reynolds number is that the friction factor is greater than it would be for a smooth pipe at that Reynolds number—how much greater the friction factor may be will depend upon how rough the pipe is, and there is no simple way to put pipe roughness into numerical terms.

Most of the laboratory work on pipe flow has been done with drawn brass pipe or tubing, the pipes varying in inside diameter from about 0.012 to 0.42 ft. The range of Reynolds numbers covered in these experiments was from about 1,000 to about 3,200,000. The work was done by many investigators in laboratories located in various parts of the world. While not every investigator used pipes of all the diameters, and while the tests did not cover the entire range of Reynolds numbers with each pipe, there is a considerable overlap in both diameter and Reynolds numbers; to the extent that the results do overlap they are in agreement, and on the basis of all the evidence available it appears that commercial drawn brass pipes and tubing are smooth, to a Reynolds number of 3,200,000 for

(Continued on page 256)

CONTAMINATION CONTROL

in Products Pipe Lines

by Edwin A. Birge

MECHANICAL problems of batching are discussed in this article in relation to the unavoidable but controllable (to some extent) commingling which takes place within the region of contact when two products having different characteristics are pumped through the same line.

The commingling between two products in the region of contact, as they are pumped through the line, will be termed in this discussion "contamination." "Spread of contamination" will refer to the quantity of commingled material extending from pure product of the leading material to pure product of the material following in the pipe line.

There have been numerous papers written which attempt scientifically to forecast the extent of this spread of contamination between petroleum products in pipe lines. It is probable that some of the data in previous articles were based upon laboratory tests with fluids which did not closely resemble petroleum products in their tendencies to mix with other fluids, nor in their physical characteristics. As a result, some of the equations offered to describe the contamination in products lines do not hold for actual operations. In one such instance an equation indicated 100 times more contamination than actually occurs in Plantation's system; in another, twice as much. With this in mind it was thought that data which will describe the **actual** spread in products lines were badly needed, even though the scientific explanation of all the factors involved was not available.

The following treatment of the problem of contamination spread is based upon data accumulated during 5 years of operation on Plantation Pipe Line; and it is submitted in the hope that it will prove helpful to those anticipating the construction of new products pipe lines.

It should be understood that the contamination spread data which follows are applicable only to liquid petroleum products having physical characteristics lying within the range of the products used in the tests. It is believed that these data will not apply to products which are insoluble in each other.

Sources of Contamination

There are three sources of contamination in a products pipe line, namely:

The mixing of products attributable to:

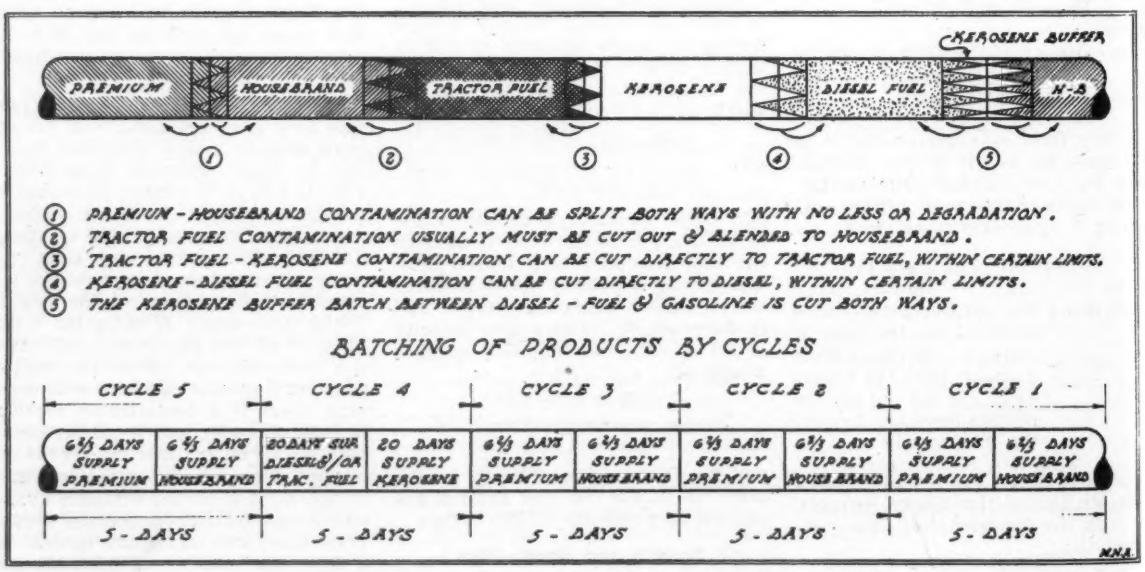
1. Design.
2. Operating procedures,
3. The mixture between products which normally occurs when two miscible petroleum products of different specifications are pumped through the pipe line, one following, and in contact with, the other.

In the following discussion each of these factors will be examined and

EDWIN A. BIRGE, eastern division superintendent, Plantation Pipe Line Co., started in the oil industry with Oklahoma Pipe Line Co. where he spent 10 years in all phases of operations serving as dispatcher, district foreman's clerk, and general superintendent's clerk. During this period he studied petroleum engineering at University of Tulsa.

Birge transferred from Oklahoma Pipe Line Co. to Plantation on January 1, 1942, as chief dispatcher. He held this position until January 1, 1947, when he was promoted to his present post.

In his capacity as chief dispatcher with Plantation, Birge made extensive studies in the field of reduction of commingling between batches of refined products during their movement through closed-tube pipeline systems. Acknowledgment is given by Birge for significant data from Floyd E. Warterfield, Jr., former vice president, Plantation Pipe Line Co., now president, Oklahoma Engineering Co., included in this article.


KEROSENE BUFFER
PREMIUM
HOUSE BRAND
TRACTOR FUEL
KEROSENE
DIESEL FUEL
M-S
1
2
3
4
5
1 PREMIUM - HOUSEBRAND CONTAMINATION CAN BE SPLIT BOTH WAYS WITH NO LESS OR DEGRADATION.
2 TRACTOR FUEL CONTAMINATION USUALLY MUST BE CUT OUT & BLENDED TO HOUSEBRAND.
3 TRACTOR FUEL - KEROSENE CONTAMINATION CAN BE CUT DIRECTLY TO TRACTOR FUEL, WITHIN CERTAIN LIMITS.
4 KEROSENE - DIESEL FUEL CONTAMINATION CAN BE CUT DIRECTLY TO DIESEL, WITHIN CERTAIN LIMITS.
5 THE KEROSENE BUFFER BATCH BETWEEN DIESEL - FUEL & GASOLINE IS CUT BOTH WAYS.
BATCHING OF PRODUCTS BY CYCLES
CYCLE 5
CYCLE 4
CYCLE 3
CYCLE 2
CYCLE 1
6 2/3 DAYS SUPPLY PREMIUM
6 2/3 DAYS SUPPLY HOUSE BRAND
20 DAYS SUP. DIESEL & OR TRAC. FUEL
20 DAYS SUPPLY KEROSENE
6 2/3 DAYS SUPPLY PREMIUM
6 2/3 DAYS SUPPLY HOUSE BRAND
6 2/3 DAYS SUPPLY PREMIUM
6 2/3 DAYS SUPPLY HOUSE BRAND
6 2/3 DAYS SUPPLY PREMIUM
6 2/3 DAYS SUPPLY HOUSE BRAND
5 - DAYS
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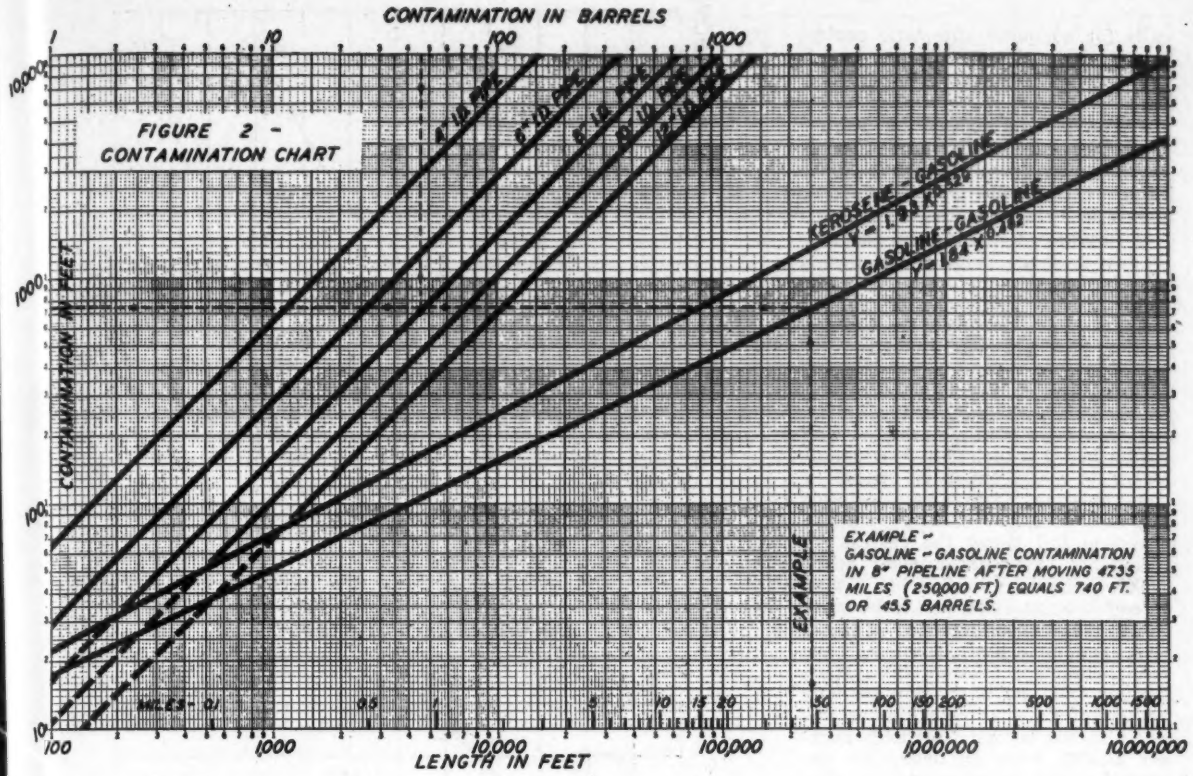
MHA

Fig. 1—**Pumping sequence for contamination control**


CONTAMINATION IN BARRELS
FIGURE 2 - CONTAMINATION CHART
CONTAMINATION IN FEET
LENGTH IN FEET
KEROSENE - GASOLINE
GASOLINE - GASOLINE
EXAMPLE
EXAMPLE - GASOLINE CONTAMINATION IN 8" PIPELINE AFTER MOVING 4735 MILES (250000 FT.) EQUALS 740 FT. OR 45.5 BARRELS.

suggestions will be made for holding to a minimum the contamination spread attributable to each.

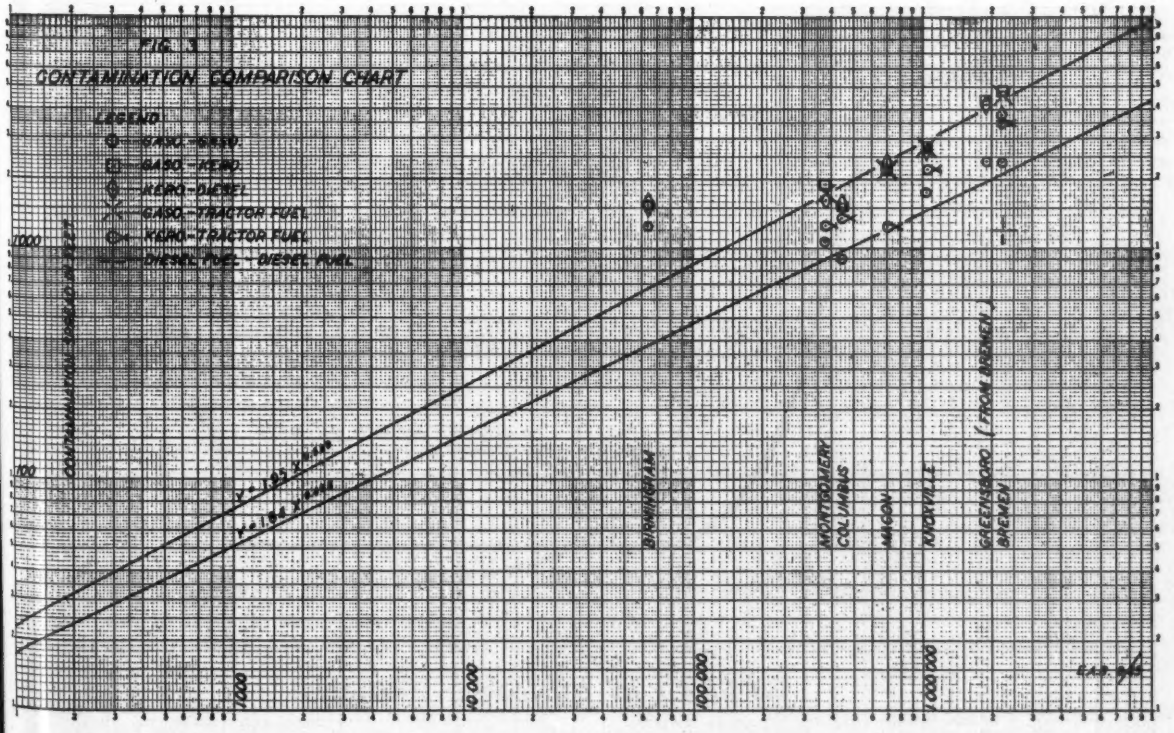
Design of Pumping Facilities

In designing a products pipe line for minimum contamination between products, the following fundamental principles should be considered:

1. Select a size of pipe such that **turbulent flow will be maintained at all times.**

2. A single-tube system should be planned. Loops in the line are contamination spreaders.

3. Design for "closed line" operation, with one station pumping directly into the suction of the downstream station. No "float" tanks to spread contamination. This, of course,



calls for adequate automatic control to protect equipment against excess pressures and unfavorable line conditions.

4. The lines through pumps, scraper traps, hay tanks, etc., should be as streamlined as possible. Stubouts, for future connections, and dead spots should be held to a minimum.

5. Provide adequate sump facilities so any drainage from pump glands, or other equipment, will go to the sump quickly and can be pumped back into the stream **into the contamination plug between products.** This will leave the sump free for the new product.

Considering these principles of design in a little more detail: it is well established that turbulent flow is necessary to avoid excessive spread of contamination. Experiments, wherein the rate of flow (velocity) was allowed to fall below the critical for turbulence (Reynolds number below 3,000), produced relatively rapid spread of contamination. On the other hand, diesel fuel against kerosine, and kerosine against gasoline, have been handled in Plantation's system, through 4, 8, and 10-in. pipe, for long periods of time, at velocities as low as 0.5 ft. per second **(Reynolds number 20,000),** with no detectable **abnormal** spread in contamination. This certainly indicates that, as long as flow remains well within the turbu-

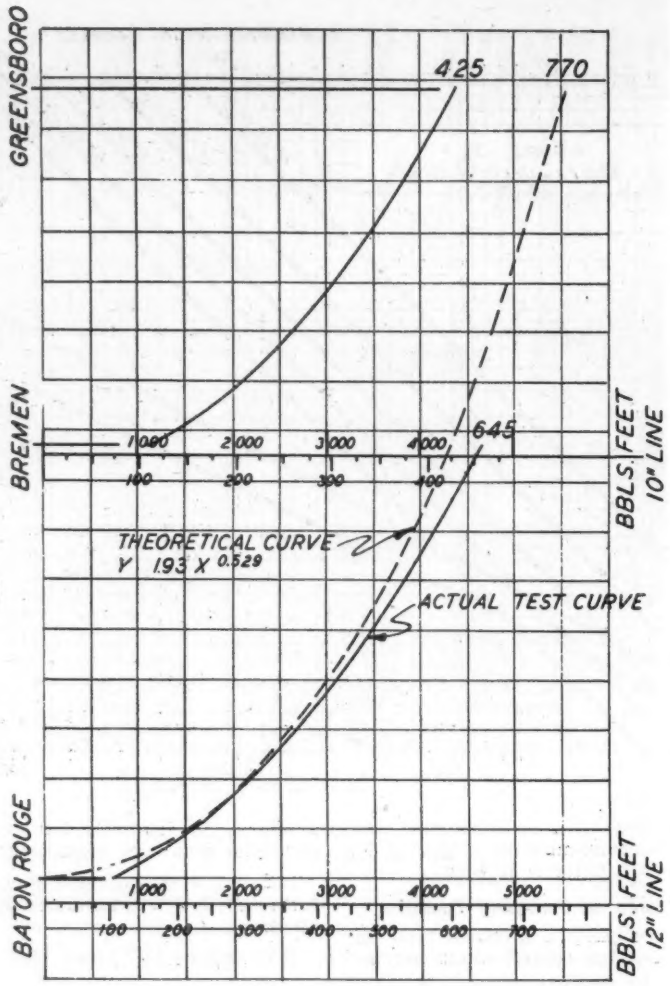
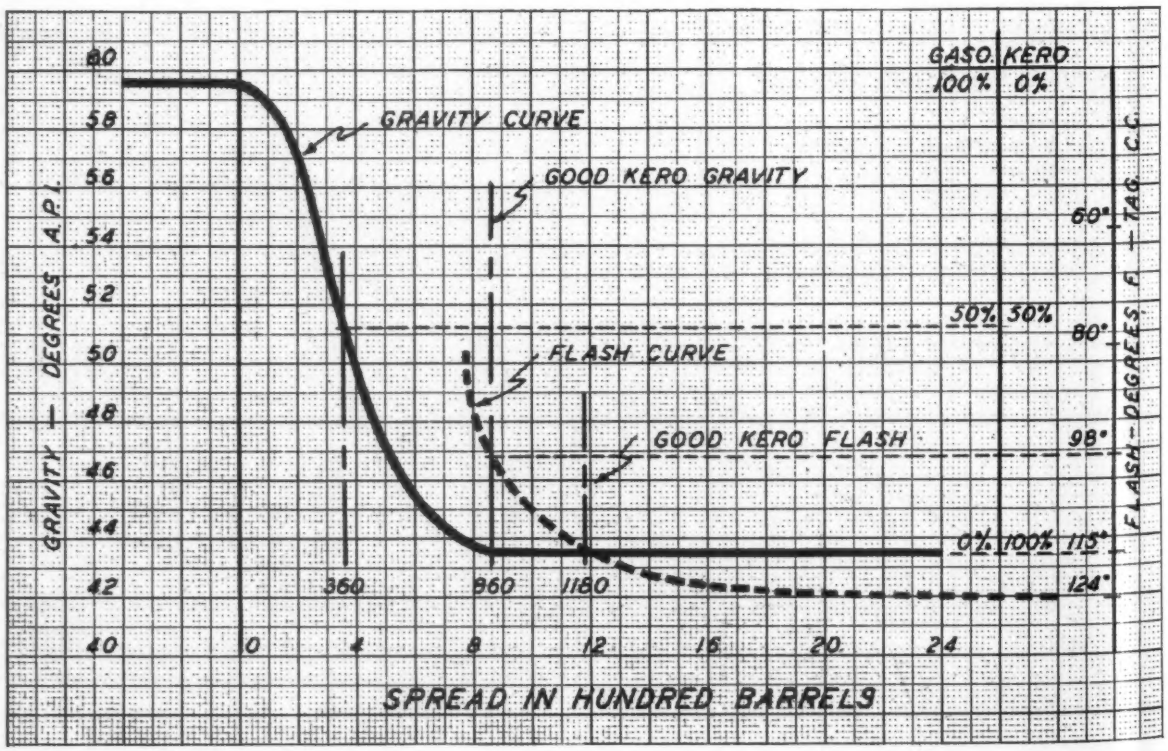


Fig. 4—(Right) Contamination spread, 12-in. and 10-in. lines

Fig. 5—(Below) Comparison of contamination by gravity and flash



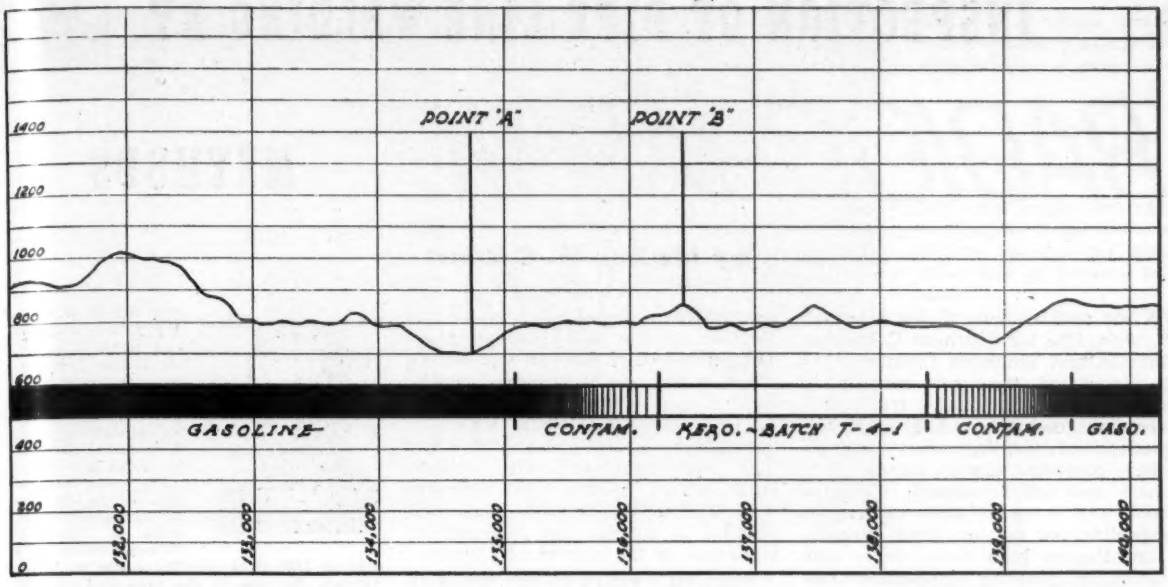
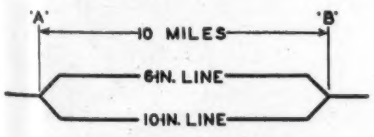


Fig. 6—Segment of profile, BR—LG 4-in. line, showing location of kerosine-gasoline contamination during 57-hour shutdown

lent range, velocity has no apparent effect upon the spread of contamination. This disproves the previously accepted rule-of-thumb hypothesis that flow must not fall below 2½ ft. per second to avoid excessive spread of contamination.

A discussion of the factors known to influence the spread of contamination and a method for determining the approximate extent of such contamination are given later in this discussion.

Concerning (2), when there are loops in products lines, a given pressure drop across a section containing two lines of different diameter, operating as a parallel system, would produce flow of different velocities in the two legs. For this reason, the junction between two products, although entering one end of the looped system at the same time, would not emerge simultaneously from the other end. This would cause spread of contamination. As an example, imagine a section of 10-in. line having a 6-in. loop, as shown in the sketch below.



Using the basic formula for flow in pipes:

$$h = f \frac{L}{D} \frac{V^2}{2g}$$*

wherein:

f = Friction factor
L = Length of line
V = Velocity of stream
h = Head in feet (loss of head account friction)

*Schoder and Dawson, "Hydraulics."

g = Acceleration of gravity
D = Diameter of pipe

Solving for V:

$$V = \sqrt{2gh/fL} \times \sqrt{D}$$

Assuming any given "h" at points A and B: f will not be exactly the same in both pipes, but the variation will not be sufficient to affect this illustration.

Let:

L = Length for both sections
D_6 = Diameter of 6-in. pipe, in feet = 0.5
D_{10} = Diameter of 10-in. pipe, in feet = 0.83
V_6 = Velocity in 6-in. pipe
V_{10} = Velocity in 10-in. pipe

Then:

$$\frac{V_6}{V_{10}} = \frac{\sqrt{2gh/fL} \times \sqrt{D_6}}{\sqrt{2gh/fL} \times \sqrt{D_{10}}}$$

and

$$V_6 = V_{10} \times \frac{\sqrt{0.5}}{\sqrt{0.83}}$$

$$= V_{10} \times \frac{0.71}{0.91}$$

= approx. 78 per cent of V_{10}

This indicates that the velocity in the 6-in. line would be only 78 per cent of the velocity in the 10-in. line. A junction between housebrand and kerosine, entering the system at A, simultaneously, would be 2.2 miles from B in the 6-in. section, when it arrived at B in the 10-in. leg. The 6-in. leg would therefore feed gasoline into the kerosine at B until the 6-in. leg was flushed clear of gasoline. Since the velocity in the 6-in. leg is only 0.78 of the velocity in the 10-in. leg, 2.2/0.78 or 2.8 miles of

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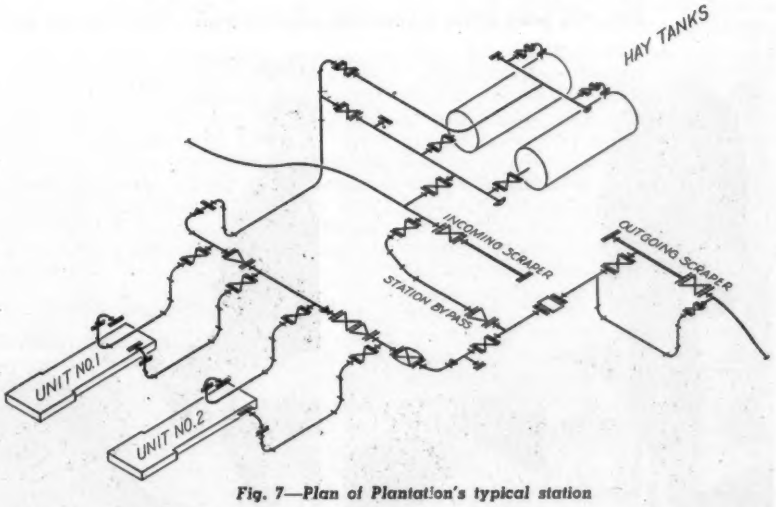


Fig. 7—Plan of Plantation's typical station

INSPECTION OF PIPE-LINE WELDING BY RADIOGRAPHIC METHODS

by Walter W. Offner

IN the construction of the 214-mile 30-in. line for Southern California Gas Co. and Southern Counties Gas Co., each of the two spreads is equipped with an X-ray truck and crew assigned for radiographic inspection of welding. However, on other projects where spreads are small and not far apart, a single truck and crew is able to handle inspection for two or three spreads.

So effective have been results that customary welding inspection has been completely eliminated on projects where radiographic inspection is used.

The radiographic technique utilizing gamma rays is being utilized in conjunction with the welding operations of H. C. Price Co., contractor on the California line. As a result of the development of portable equipment, it is possible to examine negatives on the right-of-way within an hour after a welded joint has cooled.

The Southern California project is the second major undertaking with a gamma-ray inspection. The first inspection of this kind was done on Standard Oil Co. of California's 18-in. line from Kettleman contracted by the Bechtel interests.

Usually, at least one weld per welder is inspected every day on the Southern California line; this amounts to approximately a 10 to 15 per cent inspection of all field welds. The weld to be radiographed is usually selected by the inspector who keeps records of the welders. This record gives a consecutive radiographic number and location of the weld radiographed. This consecutive number appears on the film and any defect can thus be located readily. This provides a permanent record of welds which is valuable for future use after the line has been completed. The records show which welder has difficulty with welding in the field. Thus, it is possible to correct and improve the technique of the individual welder.

Since all welders on the Southern California 30-in. line were required to make test samples which were thoroughly inspected both physically and radiographically, only competent welders were able to qualify. Incompetent welders were eliminated at the start.

Earliest Use

The use of radium for inspection purposes dates back to about 1925. Radiation energy is released in the form of waves resulting from the rearrangement of electrons in the unstable atoms of radioactive elements. The wave length of these energy waves has been determined to range between 0.005 and 1.4 angstroms. Atomic decay, in addition to creating gamma rays, is accompanied by the release of heat. Such heat, when set free by an atomic bomb, is the cause of its great destructiveness. The resulting radioactivity from an explosion of an atomic bomb is not yet fully understood by atomic scientists.

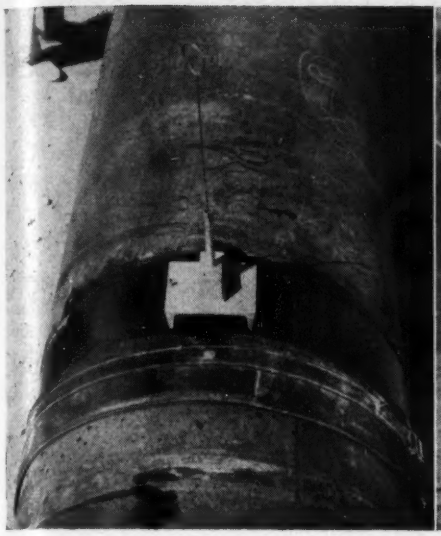
Gamma rays with their extremely short wave lengths, penetrate materials and are not reflected like the longer rays including light rays. When these waves encounter a spot in the material where the density has been changed, such as a gas pocket or a slag inclusion in a weld, it happens that more waves pass through such areas of lesser density; consequently, these defects are recorded on the radiographic film as

WALTER W. OFFNER, president and technical director, X-Ray Engineering Co., was born February 15, 1906, at Munich, Germany. He graduated from Technical University of Augsburg, Germany, as electrical engineer in 1927, and did postgraduate work in 1930-31 at Chicago University and in 1939-40 at the University of Washington. He was in the tube and test department of General Electric X-Ray Corp., Chicago, 1930-37.

From 1938, when he founded Industrial X-Ray Laboratories, Seattle, until 1946 when he formed X-Ray Engineering Co., Offner was president, Industrial X-Ray Laboratories, Inc. (1940); vice president, Standard X-Ray Sales Co. (1941); and partner in Industrial X-Ray Engineers (1943).

In the past 7 years he has radiographed welding of penstocks of Grand Coulee and Shasta Dams; also wartime welding in shipbuilding and army tank armor fabrication. Last year he radiographed welding of an 18-in. crude-oil pipe line. This year he radiographed welding on the Southern California 214-mile 30-in. natural-gas line.

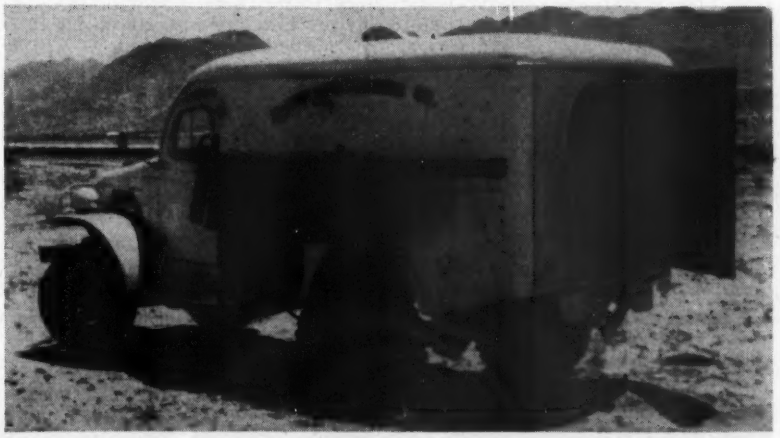
Left: Hole being drilled for inserting radium capsule. Right: Film belt and radium being placed in position



Extreme left: Radium capsule holding equipment on film belt while exposure is made

Left: Radiograph laboratory truck passing under 30-in. natural-gas pipe line laid across Chino Hills in Southern California

Below: Processed radiograph negatives being dried on the side of laboratory truck near pipe-line right-of-way in California



spots darker than the remainder of the weld which is photographed.

The weld-inspection method by the radiographic procedure is actually comparatively simple, consisting of placing the source of radiation such as X-rays or gamma rays inside or, in some cases, outside of the welded seam with the radiographic film on the opposite side. Exposure time depends on the source of radiation, the thickness of the pipe walls, and the diameter of the pipe.

Refrigerator tanks designed and built by X-Ray Engineering Co. of San Francisco are used for processing the exposed film. Such tanks installed in an insulated truck enable the radiographer to process the film near the right-of-way. On completion of developing, the negatives may be immediately analyzed. Rapid processing and analysis are important for the effectiveness of this inspection because it makes possible the immediate correction of faulty technique without the expense of cutting out welds.

According to customary procedure, joints cut out for the inspection of welding have been paid for by the owner if the weld has been found to be sound. If the weld has been below standard, the contractor has had to pay.

The radiographic method makes it possible to eliminate expense to the pipe-line owner for cut outs. Defectively welded joints will be the only ones cut out. To cut and replace a joint is rather expensive, especially on large lines. There are no means, except radiography, to determine whether the two welded seams which replace the defective one are better or worse than the weld eliminated. Radiography gives the pipe line owner 10 times more inspection at the cost of one welded seam cut out and rewelded than he would obtain from other methods of inspection. The contractor benefits to an important extent by this method.

On some projects, one welded joint per welder has been cut out each week for testing and inspection purposes at the cost of the contractor or the owner, as the case happened to be. If these joints had been radiographed, it is unlikely that more than one or two would have been cut.

The welding engineer has an opportunity to correct faulty welding technique which sometimes is discovered even in the work of good welders. Skilled welders have pride in improving their technique through sound criticism. Usually, a practical demonstration shows the welder that the film data provides significant information regarding the quality of his work.

Standards Jointly Established

The owner of the pipe line, the construction contractor, and the X-ray service organization jointly establish standards and specifications which include such details as the types and sizes of welding rods and the types of welding equipment, the method of preparing the pipe welds, and the radiographic technique to be applied. Radiographic standards must be based on physical tests made with weld samples containing the defects revealed on the radiographic film. Defects which may effect the joint efficiency are: burned-through areas, lack of penetration, undercuts (inside and outside) slag and gas intrusions, and pipe misalignment.

Since the incompetent handling of radium stored in heavy lead boxes is very dangerous, only thoroughly reliable men can be used by an X-ray service organization. In addition to the qualifications mentioned, the radiographer must be well advised in weld engineering and weld inspection in order to aid the welding engineers, the inspectors, and the welders themselves. Equipment of the X-Ray Engineering Co. for radiographic inspection of the Southern California 30-in. line was designed to withstand extreme weather conditions found in desert and mountainous country.

Radiography does not impede construction. It is a new instrument for insuring soundness of an economically constructed pipe line.

Delaware River Crossing Laid In Three-Line Sections

by Charles W. Shaeffer

Charles W. Shaeffer has directed the building of nearly 700 miles of products lines for Socony-Vacuum Oil Co., Inc., interests, while serving as manager of the Socony-Vacuum Providence, refinery.

He operated New England's first products line constructed from Providence to Springfield and Worcester in 1931. Pipe-line construction supervised by Shaeffer includes the Springfield-Hartford spur, Buffalo-Syracuse line, the Seneca Falls-Ithaca-Elmira-Binghamton line, and the Delaware River-Midland, Pa., line.

Shaeffer was retired this year after service in Standard Oil Co. of New York and Socony-Vacuum operations. Before going to the Providence plant, he was in charge of Standard Oil Co. of New York's Long Island refinery.

THE Socony-Vacuum Oil Co., Inc., pipe line from Paulsboro, N. J., to Midland, Pa., was started in 1941 when the company laid three lines across the Delaware River from its refinery to a point on the Pennsylvania shore just south of the old Hog Island shipyard, a distance of approximately 6,000 ft.

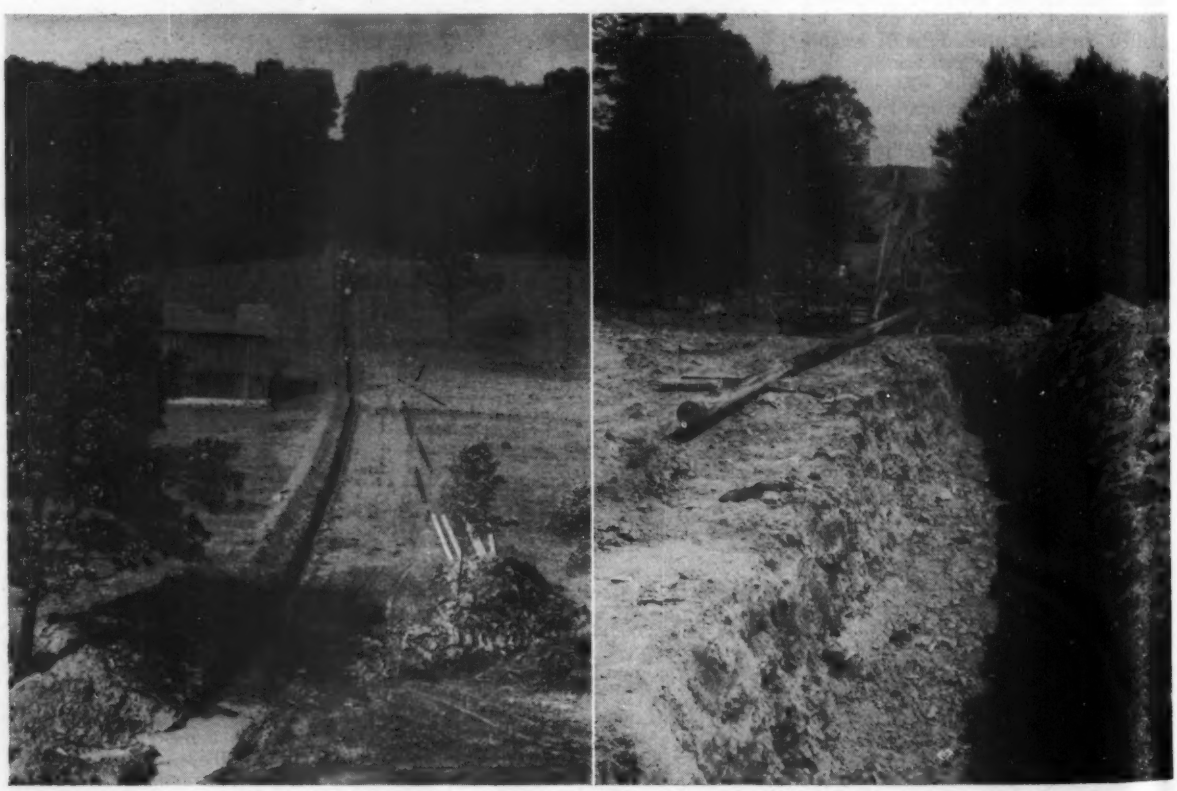
The channel is 1,000 ft. wide and is dredged to a depth of 40 ft. Government engineers specified that for the first 1,000 ft. the pipe trench should be deep enough to maintain a minimum depth from mean low water to the top of the pipe of 56 ft., a depth of 43 ft. for the next 800 ft., and a depth of 16 ft. for the next 2,000 ft. In all, 200,000 cu. yd. of material was dredged, scowed away, and dumped. Government engineers also specified that due to the heavy weekday traffic on the river, the lines would have to be laid across the channel on a Sunday and within a 4-hour period. All planning had to be done to meet these requirements.

The three pipes were welded up in 500-ft. sections parallel to the New Jersey shore on company property. They were arranged with the 12-in. pipe in the center, the 10-in. downstream on 24-in. centers, and the 8-in. upstream on 36-in. centers. They were held apart with spreaders of 10-in. channel iron placed each 100 ft. along the lines and bolted to the pipes with 1-in. U-bolts. Cast-iron river clamps were placed on the lines at 20-ft. intervals across the navigable channel and at 40-ft. intervals outside the channel.

When the first 500 ft. was ready, it was loaded on a 500-ft. train of five river barges by cranes, tractors, and winch lines and arranged along the sides of the deck, leaving space down the center for laying operations. Three tracks of 80-lb. railroad rails were laid down the center deck. The rails were spaced so that each pair would support one pipe line under the flanges of the cast-iron river clamps, thus protecting the coating as the lines slid along the rails.

The first 500-ft. section was pushed off the stern of the barge train out of the channel and along the New Jersey shore and suspended in the water by being swung under pairs

Left: Ditching for 350-mile Paulsboro, N. J.-Midland, Pa., products line. Right: Cleaning machine operating on pipe to be laid at road crossing



Left: Tack welding a joint which has been added to the line by pipe gang using the stovepipe methods. Right: Lowering in products line near the Pittsburgh area

of cylindrical pontoons which were spaced each 100 ft.

The second 500-ft. section was placed on the rails and the ends joined to the first section. The second section was then pushed overboard and suspended on pontoons. The operation was repeated for the third section but that one remained on the barges ready to be pushed overboard.

Sunday, December 14, 1941, everything was in readiness. The barge train and the pontoons were swung into position over the trench and the shore end anchored in place on the New Jersey shore. The 1,000 ft. of pipe, which was swung under the pontoons, was lowered into the trench with ropes. The barges were then pushed from under the third section of pipe. The other sections were handled the same way until a point in the center of the stream was reached. From there on, there was not sufficient water to float the equipment so each pipe was pulled separately from the barges by equipment set up on the Pennsylvania shore.

What made this job more difficult was the swift current, high winds, fog, ice, and ice floes. If the work could have been carried on during the summer, most of these troubles would not have been encountered.

Immediately following the laying of the line, one of them (the 8-in.) was used. A 6-in. line was connected to it and extended to the Gibson Point bulk station.

In 1945, it was decided to use the 12-in. for the Midland line. This line had to be planned so that in the future it would be possible to lay a northern spur and also one to the south.

With this thought in view, the first 24 miles is 12-in. pipe, followed by 42½ miles of 10-in.; the remainder of 242 miles is 8 in. There are 4-in. spur lines laid to Lancaster, Harrisburg, Altoona, McKees Rocks—a total of 17 miles. The terminals at Malvern, Mount Union, Cramer, and Irwin are located on the main line.

All of the 12-in., 10-in., 4-in. and a large percentage of the 8-in. are coated and wrapped. River crossings are laid with extra-weight pipe and are specially wrapped. Electrolytic connections have been installed along the entire length of the line.

Telephone service is leased from the American Telephone & Telegraph.

The pump at Paulsboro is reciprocating and is driven by a diesel engine equipped for dual feed (gas or oil) and it is also equipped with a supercharger.

One-Booster Station

There is one booster station at McCrea, about 130 miles from Paulsboro. This also has a reciprocating pump driven by a diesel engine equipped with a supercharger.

The circulating water from the jackets of the engines at Paulsboro and McCrea is cooled by the products flowing through the pipe line. The tubular exchangers generally used for this purpose were replaced by a jacket placed around the outside of the line. This construction has been in use on another line and has been satisfactory. It has a low first cost and is practically free from trouble.

The line handles all grades of gasoline, kerosine, and household fuel oil.

Before the products enter the line, they are passed through dehydrators. Experience on other lines of the company has proved that the use of this system eliminates the need for passing scrapers through the line. Careful operating, coupled with the use of sight glasses and gravity apparatus, has given very satisfactory batching.

The Pennsylvania terrain presents about all the problems that can be encountered in pipe-line construction. It has congested areas, woodlands, swamps, ledge rocks, boulders, mountains, rivers, coal mines, and gas, water, and oil lines.

The Susquehanna River crossing was a difficult one. To provide a trench for the pipe, it was necessary to drill and blast for the entire width of 3,000 ft. Twice after the work started, floods occurred which washed away anchor posts and the cable attached to them, equipment had to be moved to high ground and work suspended until the waters had receded to normal level.

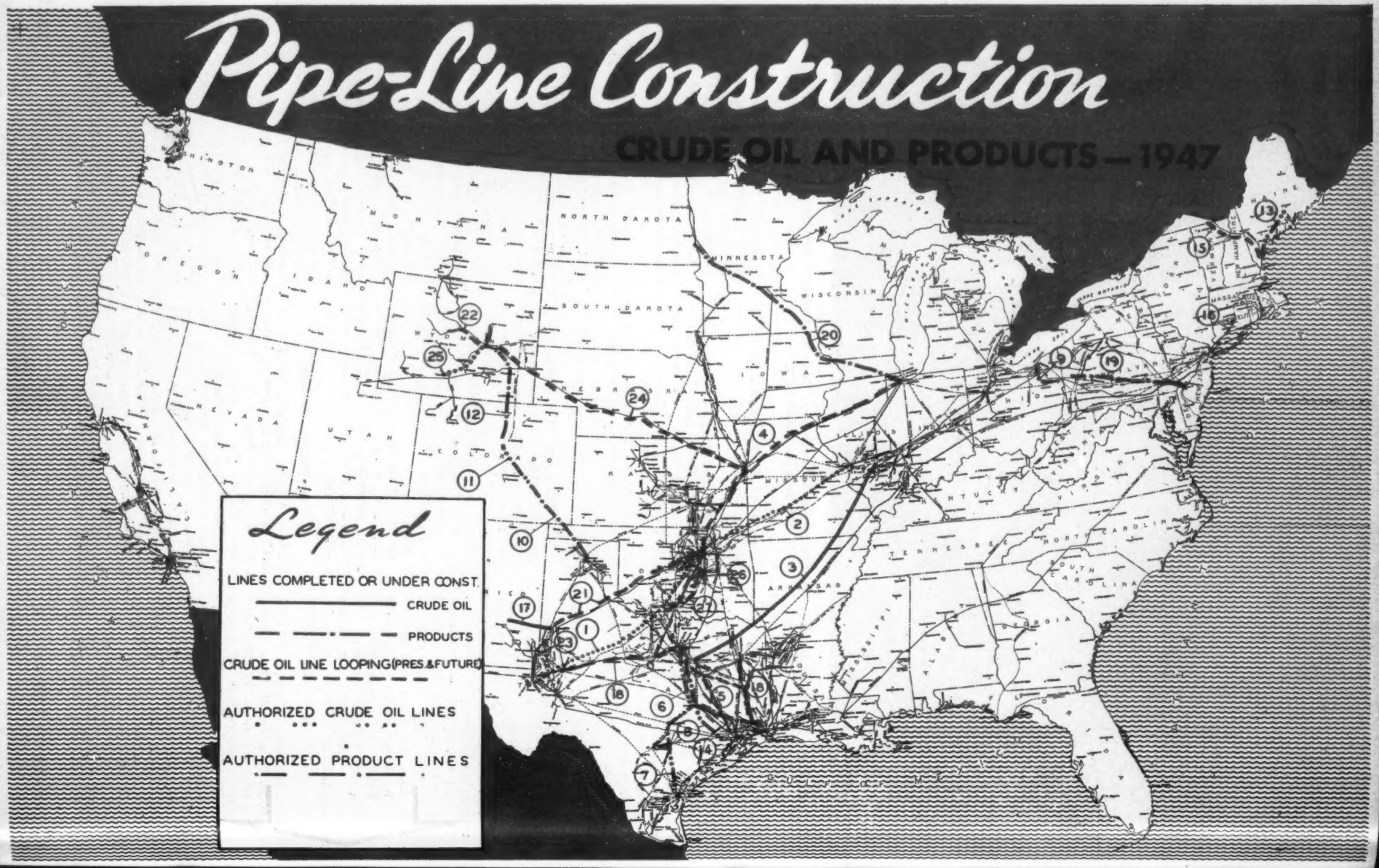
Finally, the drilling was completed and everything in readiness for blasting. The pictures taken of the blasting will give some idea of how spectacular it was.

The Blue, Tuscarora, Jack, and Tussey mountains, with their elevations going up to 2,500 ft., all had to be surmounted with all the construction difficulties of mountain work.

However, the entire line was completed and in service December 31, 1946.

Pipe-Line Construction

CRUDE OIL AND PRODUCTS — 1947



1947 MAJOR CRUDE AND PRODUCTS LINES.

Review of 1947 Construction; Forecast for Coming Years

by Paul Reed

PIPE-LINE plans of recent weeks emphasize more definitely the trends already indicated by developments earlier this year. The majority of the new projects totaling 2,325 miles, announced since the last part of July will be carried out for the purpose of amplifying programs for which previous preparations had been made. These new projects, when added to the 21,600-mile total of projects announced in the first half of 1947, give a total of 23,925 miles of major projects including 7,604 miles of crude-oil lines, 5,327 miles of products lines, and 10,944 miles of natural-gas lines in the United States. By adding the 5,200 miles planned for major foreign projects, the grand total for important projects for the 1947-51 period is 28,640 miles.

Later announcements of new projects indicate that the industry is now thinking in terms of programs spreading over the entire 1947-51 period. Previously pipe-line plans have not been generally known more than a year or two in advance. Most lines planned for 1951 would be commenced within a few months if pipe and facilities were immediately available.

Prominent among recently announced projects are two large undertakings: One is a 500-mile crude-oil line from the Southwest to meet huge demands in the Illinois area; the other is a 908-mile program to augment future gas deliveries westward to California.

Other theaters of pipe-line activity important in 1947-48 are indicated by extensive products pipe-line building in Texas, and preparations for building facilities for transmitting Hugoton and Gulf Coast gas northeastward.

1947 MAJOR CRUDE AND PRODUCTS LINES: COMPLETED—CONSTRUCTING—AUTHORIZED

Key	Type	Company	Route
1	Crude	Basin Pipe Line System (Texas, Shell, Sinclair, Empire)	Jal, N. M.—Midland, Tex.—Cushing, Okla.
2	Crude	Shell and Texas	Cushing, Okla.—Wood River, Ill.—Salem, Ill.
3	Crude	Magnolia Pipe Line Co.	Corsicana, Tex.—Patoka, Ill.
4	Crude	Stanolind Pipe Line Co.	Drumright, Okla.—Whiting, Ind.
5	Products	Magnolia Pipe Line Co.	Beaumont—Hearne, Tex.
6	Products	Texas Pipe Line Co.	Hearne—Dallas and Fort Worth, Tex.
7	Products	Sinclair Refining Co.	Corpus Christi—Luling—San Antonio—Austin—Bryan, Tex.
8	Products	Sinclair Refining Co.	Houston—Bryan—Dallas and Fort Worth, Tex.
9	Products	Sinclair Refining Co.	Akron—Youngstown—Cleveland, Ohio
10	Products	Phillips Petroleum Co.	Borger, Tex.—La Junta, Colo.
11	Products	Phillips Petroleum Co.	La Junta—Denver, Colo.
12	Products	Wyco Pipe Line Co.	Casper—Cheyenne—Denver, Colo.
13	Products	Socony-Vacuum Oil Co., Inc.	So. Portland—Augusta—Bangor, Me.
14	Crude	Texas Pipe Line Co.	West Columbia—So. Houston—Port Neches—Port Arthur, Tex.
15	Crude	Portland Pipe Line Co.	Portland—Montreal
16	Products	Connecticut Pipe Line Corp.	New Haven—Hartford
17	Crude	Stanolind Pipe Line Co.	Caprock, N. M.—Slaughter, Tex.
18	Crude	Gulf Refining Co.	Midland—Lufkin, Tex.
19	Products	Socony-Vacuum Oil Co., Inc.	Paulsboro, N. J.—Midland, Pa.
20	Products	Standard Oil Co. of Ind.	Whiting, Ind.—Moorehead, Minn.
21	Crude	Stanolind Pipe Line Co.	Slaughter, Tex.—Drumright, Okla.
22	Crude	Stanolind Pipe Line Co.	Lysite—Casper, Wyo.
23	Crude	Stanolind Pipe Line Co.	Wasson—Wheeler, Tex.
24	Crude	Stanolind Pipe Line Co.	Casper, Wyo.—Freeman, Mo.
25	Crude	Stanolind Pipe Line Co.	Casper—Warnsutter, Wyo.
26	Products	Sunray Oil Corp. and Wilcox Oil Co.	Allen—Drumright—Bristow—West Tulsa
27	Products	Sunray Oil Corp.	Allen—Duncan, Okla.

Joint Project Planned

Plans for the Shell-Texas system from Cushing, Okla., to Wood River and Salem, Ill. to solve a problem which was presented a year ago when the Basin Pipe Line System was organized. Basin is a joint ownership undertaking of Texas Pipe Line Co., Shell Pipe Line Corp., Sinclair Refining Co., and Empire Pipeline Co. for building a 517-mile, 20, 22, and 24-in. crude-oil line from Jal, N. M., to Cushing, Okla. The Shell-Texas project extending northeastward from Cushing consists of a 439-mile, 20-in. line to be built by Shell Pipe Line Corp. to Wood River, and a 61-mile, 16-in. extension from Wood River to Salem, to be built by Texas Pipe Line Co. Capacity of the Shell-Texas system has been announced as 150,000 bbl. daily.

Basin is now building tanks and other facilities in West Texas. Contracts are expected to be let by Basin for pipe laying in October. As the work progresses there will probably be a period in which pipe laying will be going on simultaneously for both the Basin System and the Cushing-Wood River-Salem extension. The latter is likely to be finished about 3 months after Basin is completed.

Engineering studies are now being carried on by Texas-Empire Pipe Line Co. to investigate possibilities for building facilities for forwarding crude oil from the Salem area to the Chicago refining area.

While Magnolia Pipe Line Co.'s 647-mile 20-in. Corsicana, Tex.-Patoka, Ill., line now under construction will start with initial capacity of 102,000 bbl., it may be later increased by successive steps to 127,000 bbl., 152,000 bbl., and later to 200,000 bbl. daily or more.

The 260 miles of 20 and 22-in. looping for Stanolind Pipe Line Co. now under construction in the La Plata, Mo.,-Manhattan, Ill., section will link the previous looping begun in 1946. Thus Stanolind integrates a continuous new 632-mile line from Drumright, Okla., to Whiting, Ind., consisting of 20-in. and 22-in. pipe from

(See tables on next page)
(Continued on page 293)

TABLE 1 — MAJOR DOMESTIC CRUDE-OIL PROJECTS

1947-1951 (announced)

Company—	Miles	Inch	Status	Location
Standish Pipe Line Co.	289	12	Planned	Goldsmith, Borger, Tex.
Magnolia Pipe Line Co.	650	20	Under way	Corsicana, Tex.-Patoka, Ill.
Stanolind Pipe Line Co.	197	12-16	Planned	Loops Casper, Wyo.-Freeman, Mo.
Stanolind Pipe Line Co.	130	8	Planned	Wamsutter to Casper, Wyo.
Stanolind Pipe Line Co.	178	20	Completed	Drumright, Okla.-Freeman, Mo.
Stanolind Pipe Line Co.	260	20-22	Under way	La Plata, Mo.-Manhattan, Ill., as part of 632-mile 20-in. Drumright, Okla.-Whiting, Ind., looping program to be completed in 1947.
Stanolind Pipe Line Co.	70	12	Planned	Lysite-Casper, Wyo. looping
Stanolind Pipe Line Co.	50	8	Planned	Post pool—Petersburg, Tex.
Stanolind Pipe Line Co.	80	16	Planned	Wheeler-Wasson, Tex. extension
Stanolind Pipe Line Co.	265	16	Planned	Slaughter, Tex.-Drumright, Okla. looping
Stanolind Pipe Line Co.	69	8	Under way	Caprock, N. M.-Slaughter, Tex.
Interstate Oil Pipe Line Co.	50	12	Under way	Oklahoma City-Maysville, Okla.
Phoenix Pipe Line Co.	600	8	Planned	Permian basin-Phoenix
Midway Pipe Line Co.	600	..	Planned	Permian basin-Oklahoma to Kansas
Texas Pipe Line Co.	60	16	Planned	West Columbia, Tex.-Houston
Texas Pipe Line Co.	80	22	Planned	Houston-Port Neches and Port Arthur
Texas Pipe Line Co., Shell Pipe Line Corp., Empire Pipe Line Co., Sinclair Refining Co.	500	20-22-24	Planned	Jal, N. M.-Cushing, Okla.
Shell and other companies	1,045	20	Planned	Midland, Tex.-Wilmington, Calif.
Gulf Refining Co.	105	8-10	Under way	Midland-Lufkin, Tex., loops
Portland Pipe Line Co.	300	20	Planned	Portland, Me.-Montreal
Shell-Texas	500	20-16	Planned	Cushing, Okla.-Wood River, Ill.-Salem, Ill.
Sinclair Refining Co.	50	18	Completed	Humboldt-Little Blue, Kans., looping

TABLE 2—LARGE DOMESTIC PRODUCTS-LINE PROJECTS

1947-1951 (announced)

Company—	Miles	Inch	Status	Location
Shell Pipe Line Corp.	100	6	Completed	Sheridan-Deer Park, Tex.
Standard Oil Co. (Indiana)	662	8-10	Completed	Joliet, Ill.-Moorhead, Minn., and Fargo, N. D.
Phillips Petroleum Co. and Shamrock Oil & Gas Co.	365	6	Under way	Borger, Tex.-Denver
Wyco Pipe Line Co. (Standard of Ind., Texas Co. and Socony-Vacuum Oil Co., Inc.)	267	8	Under way	Casper, Cheyenne, Wyo., Denver
Magnolia Pipe Line Co.	178	12	Under way	Beaumont-Hearne, Tex.
Texas Pipe Line Co.	172	10	Planned	Hearne-Dallas and Fort Worth area
Sinclair Refining Co.	225	6	Under way	Corpus Christi, San Antonio, Austin, Bryan, Tex.
Sinclair Refining Co.	190	6	Completed	Clinton, Cleveland, Steubenville, Ohio
Sinclair Refining Co.	850	10	Planned	Houston, Fort Worth, Dallas, Coffeyville, Kansas City
Sinclair Refining Co.	200	8	Planned	Kansas City-St. Louis (part of 3,000-mile, Houston, Chicago, Marcus Hook Project)
Connecticut Pipe Line Corp.	40	8	Planned	New Haven-Hartford
Socony-Vacuum Oil Co., Inc.	127	4-6	Planned	Portland-Bangor, Me.
Sunray Oil Corp.-Wilcox Oil Co.	83	8	Completed	Allen-Bristow-Tulsa
Socony-Vacuum Oil Co., Inc.	300	8-10-12	Completed	Paulsboro, N. J.-Midland, Pa.
Great Lakes Pipe Line Co.	54	8	Completed	Ponca City-Barnsdall, Okla.

TABLE 3 — PRINCIPAL DOMESTIC NATURAL-GAS PROJECTS

1947-1951 (announced)

Company—	Miles	Inch	Status	Location
Panhandle Eastern Pipe Line Co.	660	18-26	Programs under way	Loops
Michigan-Wisconsin Pipe Line Co.	1,069	22-26	Planned	Hansford, Tex.-Big Rapids, Mich.
Colorado-Wyoming Gas Co.	101	8-16	Planned	Cheyenne, Wyo.-Denver
United Natural Gas Co. (Pa.)	71	20	Planned	Beaver and Green Counties, Pa.
Tennessee Gas Transmission Co.	83	20	Planned	Carthage-Natchitoches
El Paso Natural Gas Co.	438	26	Planned	Permian Basin-Blythe, Calif.
El Paso Natural Gas Co.	470	26	Planned	San Juan Basin-Needles, Calif.
New York State Natural Gas Co.	155	12-16	Planned	Pennsylvania
Mid-Continent Gas Trans. Co.	400	26	Planned	Liberal, Kans.-Kansas City
Mid-Continent Gas Trans. Co.	438	22	Planned	Kansas City-St. Paul
Natural Gas Pipe Line Co. of America and Texoma Natural Gas Co.	268	26	Under way	Kansas and Nebraska loops
Colorado Interstate Gas Co.	260	20	Completed	Lakin, Kans.-Denver
Ohio Fuel Gas Co.	149	10-12-16-20	Under way	Ohio
Mississippi River Fuel Corp.	230	10-12-22	Under way	Loops Perryville, La.-St. Louis
Hope Natural Gas Co.	75	12-20		Loops
Southern Natural Gas Co.	138	20-22	Planned	Chattanooga-Lexington, Miss.
El Paso Natural Gas Co.	740	26	Under way	Eunice, N. M.-Blythe, Calif.
El Paso Natural Gas Co.	248	24	Planned	Eunice, N. M.-Dumas, Tex.
Southern Calif. Gas Co. and Southern Counties Gas Co.	214	30	Under way	Blythe, Calif.-Los Angeles
East Ohio Gas Co.	50	20	Under way	Jackson-Brook Park, Ohio
East Ohio Gas Co.	84	20	Planned	Monroe-Starky Counties, Ohio
Tennessee Gas & Trans. Co.	912	20-26	Under way	Loops
Tennessee Gas Trans. Co.	99	16	Completed	Agua Dulce-San Salvador, Tex
Memphis Natural Gas Co.	1,000	24	Planned	East Texas-Pittsburgh, Pa.
Atlantic Seaboard and Virginia Gas & Trans.	268	24	Planned	Cobb, W. Va.-Rockville, Ind.
Manufacturers Light & Heat Co. and Home Gas	130	14	Under way	Coatesville, Pa.-Port Jervis, N. Y.
United Gas Fuel Co.	100	20	Planned	Ceredo, W. Va.-Crawford, Ohio
Northern Natural Gas Co.	133	16-24	Planned	Loops
Northern Natural Gas Co.	320	26	Planned	Palmyra, Neb.-Garden City, Kans., looping
Northern Natural Gas Co.	245	24	Planned	Palmyra, Neb.-Farmington, Minn., looping
Trunkline Gas Supply Co.	885	30	Planned	Wharton County, Tex.-Keokuk, Iowa
United Gas Pipe Line Co.	93	18	Planned	Baxterville, Miss.-Mobile, Ala.
United Gas Pipe Line Co.	33	20	Planned	Carthage-Longview, Tex.
Atlantic Gulf Gas Co.	1,530	..	Planned	Alabama, Florida, Georgia, South Carolina
United Gas Fuel Co.	50	20	Under way	West Virginia
East Ohio Gas Co.	43	20	Under way	Barberton, Ohio
Panhandle Eastern Pipe Line Co.	660	..	Planned	Loop
Cities Service Gas Co.	405	26	Planned	Hugoton-Kansas City
Cities Service Gas Co.	47	12-16	Under way	Guthrie-Drumright, Okla.
Peoples Natural Gas Co.	90	..		Pennsylvania

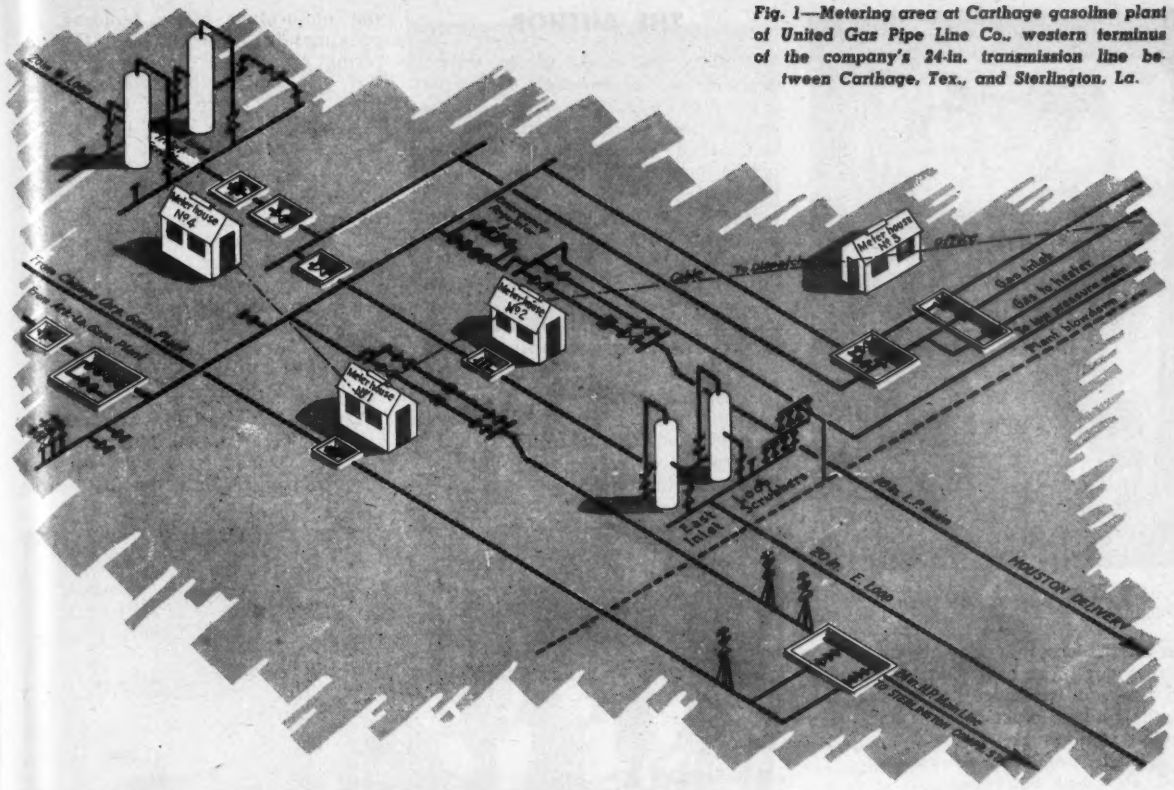


Fig. 1—Metering area at Carthage gasoline plant of United Gas Pipe Line Co., western terminus of the company's 24-in. transmission line between Carthage, Tex., and Sterlington, La.

TELEMETERING at United's Carthage Plant

by W. M. Moore

UNITED GAS PIPE LINE CO.'s Carthage gasoline plant, located at the western terminus of the company's 24-in. transmission line between Carthage, Tex., and Sterlington, La., is an example of modern plant design and control equipment essential for dependable natural-gas transmission.

Gas to and from the Carthage plant, all gas delivered to the Carthage-Sterlington 24-in. main line, and gas spilled over to the Houston line is measured in a central metering area as shown in Fig. 1. Wet gas from the principal field-gathering systems is fed to the Carthage plant. Returning dry gas from the plant is manifolded with dry gas from two other sources to provide delivery to the Carthage-Sterlington main line (at about 1,000 psi. pressure). Houston-line requirements at 300 psi. delivery pressure, are spilled over from the plant discharge at deliveries remotely controlled from the dispatcher's office.

The pressures and quantities of gas on all these separate lines must be integrated with the operations of the gas-processing plant, the field-gathering system, and the dispatching of pipe-line deliveries.

Since variations in conditions on any one line have definite effects

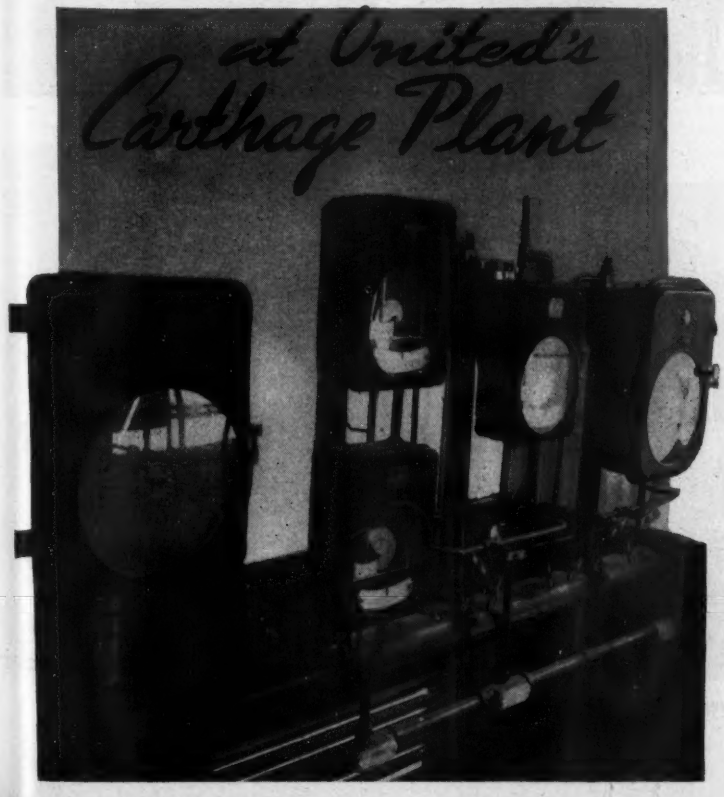


Fig. 2—Pressure, flow, and temperature transmitters

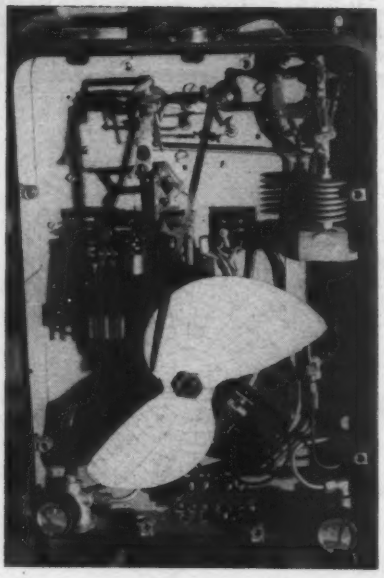


Fig. 3—Interior of flow controller

on all the other factors involved, the dispatcher must have constant access to flow and pressure readings at all times, and he must have at hand the following data:

1. Field and well deliveries.
2. Pipe-line deliveries.
3. Input from other gasoline plant.
4. Temperature of field gas.
5. Flow balancing of field lines.

The last two items are especially vital to winter operations because of the ever-present possibility of hydrate formation in the high-pressure field lines. The main gathering line around the gas field is looped so that both ends deliver gas to the plant. Observation of deliveries from both legs of the loop, with foreknowledge of well inputs, gives the dispatcher and field foreman a good picture of the condition of the field lines flow at all times.

THE AUTHOR

William Matthews Moore, now a engineer in the research department of United Gas Pipe Line Co., installed the telemetering equipment at Carthage gasoline plant and maintained it until May 1947 when he was transferred to his present position.

Moore was born and attended public schools at Edna, Tex., and spent 2 years in engineering at St. Mary's College at San Antonio. He has been in the employ of United Gas since 1930, building up an enviable record in gas-measuring equipment.

Measuring points are well centralized, but the dispatcher's office was not located adjacent to them. For reasons of accessibility and convenience, the office was located in the main-plant office building, approximately 1,000 ft. from the metering area. This distance precluded the advisability of running meter lines to the office, nor would it be desirable to have lines bearing 1,000 lb. pressure entering the plant office.

The obvious answer to the problem outlined above was one of remote control and metering or telemetering. This involves a device to convert mechanical readings to an electrical transmitter whose representatives can be picked up over direct wires or wireless by a receiver at some distance away. The receiver indications must then be reconverted to mechanical recordings or indications.

The system used at Carthage consists of five pressure transmitters, six flow transmitters, one temperature transmitter, and one flow con-

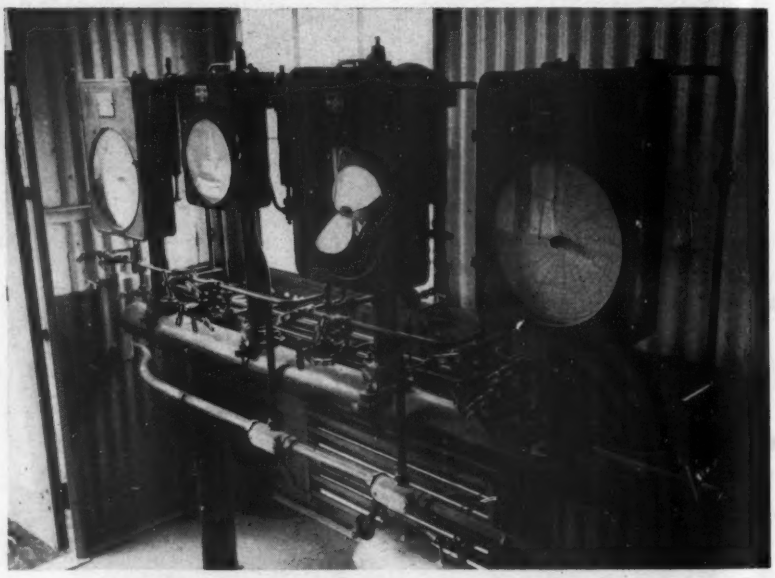


Fig. 5—View of transmitter and flow controller

Fig. 4—Meter valve, controlled from dispatcher's office

troller, operated by a remote switch from the dispatcher's office. Five of the receivers are equipped with two-pen recorders, so that corresponding differentials and static pressures can be read off the same chart. One receiver is set up to read differentials or flow only and one receiver to read temperatures only.

The transmitters are placed in the meter houses at locations from which telemetering is desired. All measured readings are taken from meter lines that also operate ordinary flow meters. The only recording transmitter is the one used to transmit temperature. This type was chosen since two charts were available with but one thermometer well and tube system required.

Signal circuits from the transmitters to the receivers are two-wire a.c. circuits, inclosed in a 26-pair lead - and - steel - sheathed submarine cable. One pair of wires is ground to reduce the induced currents of the other wires carrying alternating current. This cable is encased in concrete and buried approximately 2 ft. in the ground. One signal circuit is a superimposed a.c.-d.c. system with appropriate filters to carry two signals on one pair of wires. The a.c.-d.c. system may have been employed for the other circuits as well, thereby reducing the total number of circuits. The system also includes the circuit for the flow controller (see Figs. 3 and 4) operating by a toggle switch in the dispatcher's office. This enables the dispatcher to control the flow to the Houston line.

The telemeter principle that is employed is based on the transmission and reception of an intermitted electric current. There is no measurement of electrical values. The only variable transmitted by the system is the accurately timed "off" and "on" period of the current. Briefly, the transmitter makes and breaks an electrical circuit on a definite time cycle, and the proportion of the off and on time is determined by the measured value of the pressure, flow or temperature being transmitted. The receiver, operating on the same time cycle as the transmitter, translates the off and on phases of the current to a pen position on a chart shown in Fig. 6.

The telemetering system produces charts that check well within 1.0 per cent of the measured gas volumes as obtained from the orifice-meter charts.

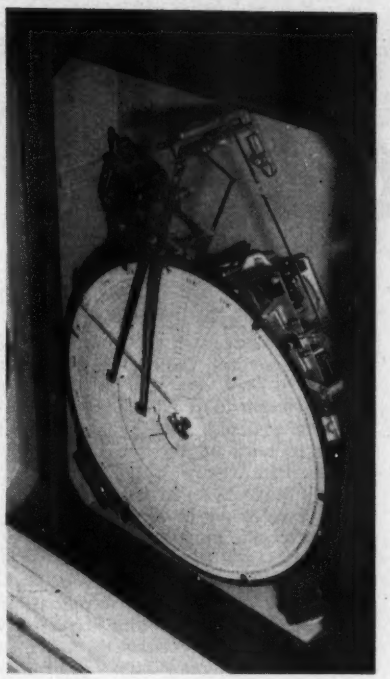


Fig. 6—Interior view of two-pen receiver

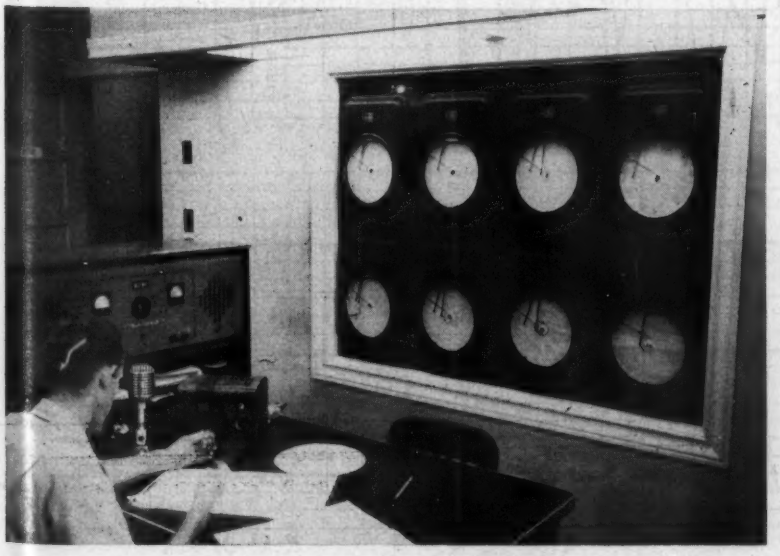


Fig. 7—Receivers in dispatcher's office

No highly erroneous readings are possible from this telemetering system, since circuit difficulties cause the recording pens on the receivers to go completely off chart. This condition produces such an extreme reading that it is evident to the dispatcher that the reading is in error. The dispatcher then will request servicing of the instrument. The system operates with very little maintenance. The principal item of servicing is cleaning and lubricating. Small adjustments are necessary from time to time; but, if intelligent lubrication practices are followed, the wear of moving parts is small. Periodic inspections are made and all bearings and gears are given a thorough cleaning with carbon tetrachloride.

The transmitters are calibrated in the usual manner of testing any measurement instrument. They are provided with an indicating scale that permits observation of the measured value being transmitted. This scale also is used in calibrating with standard test devices. A telephone circuit is provided so that the receivers can be calibrated in conjunction with the transmitters.

The use of these telemeters at Carthage has convinced the operating personnel of their accuracy and dependability. The results obtained, aided by the two-way radio system also employed to report operations to the dispatcher have contributed much to the efficient and safe operation of the Carthage gas field and gasoline plant.

Oil Companies Sued By Oyster-Bed Owners

Owners of oyster beds in four parishes in the New Orleans area have filed 19 more suits in federal court asking $5,086,194 from several oil companies for alleged damages from seismograph explosions.

This brings the total to 65 suits asking $30,000,000 in damages filed by oyster-bed owners.

Defendants in the recent suits were The Texas Co., Freeport Sulphur Co., Humble Oil & Refining Co., Danciger Oil & Refining Co., Gulf Refining Co., Lafitte Co., and California Oil Co.

Husky Oil Reorganized As Husky Rangely Oil Co.

A loan of $3,250,000 representing 40 per cent of the maximum net oil on the properties of Husky Refining Co., Cody, Wyo., has been made in the recent reorganization and refinancing of the company whereby it was incorporated as Husky Rangely Oil Co.

The entire loan was made on the 2,000 acres of producing Husky properties in Rangely field where it holds an interest with Stanolind Oil & Gas Co. and others.

An Experience With the 'MEGGER'

by W. H. Simpson

The author is pipe-line engineer for General Petroleum Corp., a position he has held for the past 5 years. Previous experience with the company includes 9 years in the land and right-of-way department, in which department he rose to chief surveyor. Simpson attended California Institute of Technology at Pasadena, and University of California at Los Angeles.

ABOUT 2 years ago a corrosion leak occurred in the mountainous region just south of Newhall in General Petroleum Co.'s 10-in. main line from the San Joaquin Valley. This was the first leak that had occurred in this section since the line was laid in 1935, and it was the cause of much concern because that section of the line transversed a rather remote territory and was walked only once a week by the line rider. The length of this section of the pipe line was 6,300 ft. and the ruggedness of the terrain made it a comparatively expensive job to recondition.

The line was not treated when it was originally laid so a return visit from "demon corrosion" could be expected at any time. Thus it behooves us to do something about it before more damage was done, ever remembering, however, that economy is a most important factor. Here was a chance to try out the "megger" in what we considered ideal country for its most efficient use. A decision was made to hold up the job of reconditioning the entire 6,300 ft. until a survey was made with it.

To those readers who are unfamiliar with the megger (manufactured by James G. Biddle, Philadelphia), and its principles, it might be well to inject a small note of explanation. The megger, or ground resistivity meter, is an instrument used to measure electrical resistance, especially that of the ground. The instrument is a double commutator generator operated by a handle that is turned at an approximate speed of 100 r.p.m., which, by means of gears, turns the generator at a much higher speed. The output is about 90 volts. Built in the instrument is a direct-reading ohmmeter which reads from 0.1 to 3,000 ohms.

The auxiliary part of the equipment consists of four iron pegs about 8 in. long which are driven into the ground an equidistance apart in a straight line, the distance apart depending upon the depth to which the average ground resistance is to be obtained; i.e., if the average resistance is to be determined to a depth of 4 ft., the four pegs must be driven into the ground at 4-ft. intervals in a straight line. These pegs are connected to four terminals in the face

(Continued on page 292)

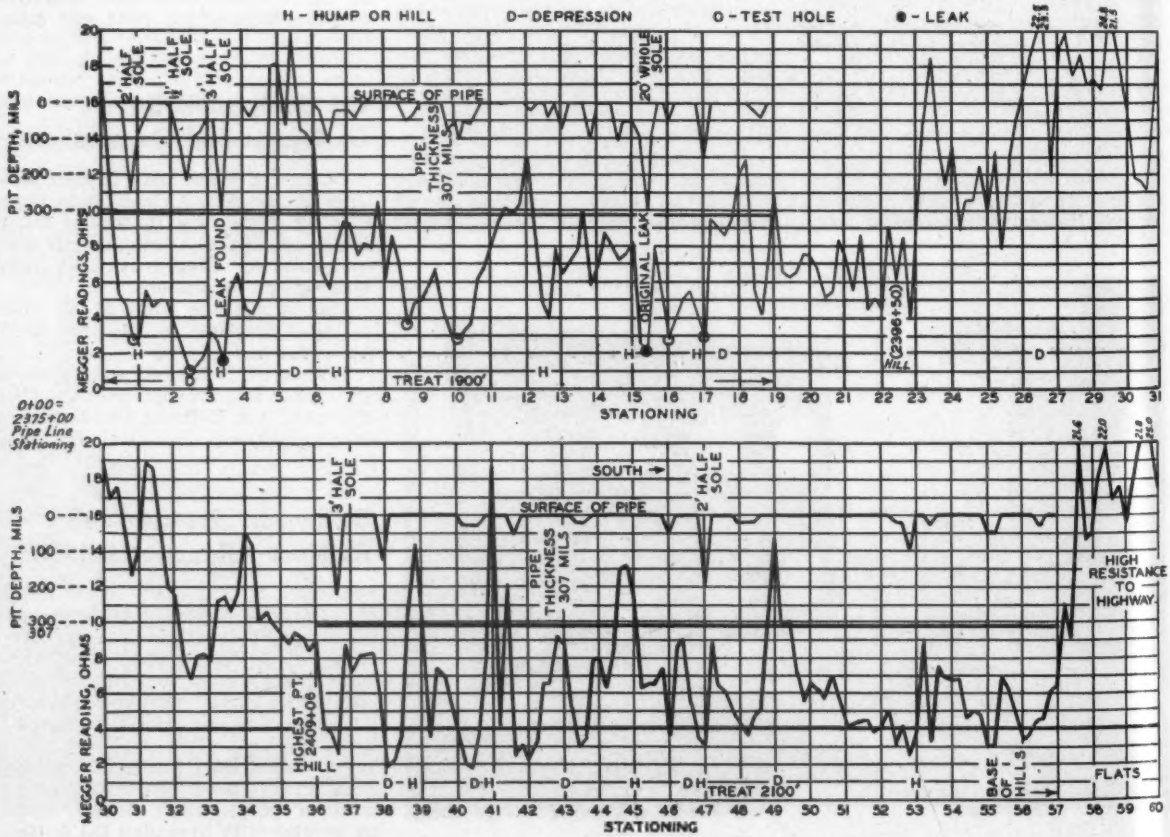


Fig. 1—Megger survey, 10-in. line No. M-70, Station 2375+00 to 2438+00, Newhall area

SAFETY-WELD COUPLING...

..on Pipe-Line Maintenance Work

by J. B. Smith

A NEW procedure for welding joints in pipe lines that are in service and under pressure has been developed by Standard Oil Co. of Ohio. The procedure, made possible through the use of the safety-weld coupling, a special device, effectively reduces the hazards of welding on operating pipe lines and minimizes loss of operating time.

As its name implies, the safety-weld coupling is primarily a safety device. It is designed to permit electric welding of a pipe-line joint while the line is under pressure and preferably while a stream is moving through it.

In making section replacements in crude-oil or gasoline pipe lines it has been common practice to use mud, asphalt, or rubber plugs for stopping up the ends of pipe during cutting and welding operations. These plugging operations are dangerous because a leaking or mistakenly opened valve may permit the oil or gasoline to enter the repair section and blow out a plug while welding or cutting is under way. In hilly country a delayed slug of oil may rush into the repair section long after the line is supposedly completely drained and thus cause a plug to blow out while work is in progress. A plug blowout, however, is not the only potential danger that has been faced by a pipe-line welder working on a repair job on a line that has been shut down. It is always hazardous to weld on a crude-oil or gasoline pipe line that has been in operation for it may contain combustible vapors.

The safest condition for welding on a crude-oil or gasoline pipe line is with the line full and with a stream moving through it. (See A.P.I. Accident Prevention Manual, paragraph 153, February 1943). The safety-weld coupling method of making section replacements eliminates all forms of plugs and permits the pipe line to be rejoined by electric welding while it is filled with a moving stream of crude oil or gasoline.

Working Principle

The working principle of the safety-weld coupling may be seen by referring to Fig. 1. The coupling consists of a steel sleeve with internal grooves near each end. Packing rings fit into these internal grooves. A stiff, putty-like lubricant is forced in behind the packing rings (through ⅛-in. pipe connections) by a special pressure gun. This lubricant, subjected to gun pressures up to 10,000 psi., squeezes the packing rings between pipe and coupling walls and creates a very effective leak-proof seal. Couplings sealed in this manner have been tested to over 1,000 psi. gasoline pressure and have not leaked a drop.

The author is research engineer in the transportation department of Standard Oil Co. (Ohio). He joined the company in 1940 and worked in the products pipe-line division until late in 1942, when he was assigned to the general engineering staff as assistant manager of the department. Since that time he has worked on varied engineering assignments connected with construction of pipe-line facilities and perfection of operating practices. Currently he is devoting his time to research and development work. He has several patents to his credit and is responsible for the development of the safety-weld coupling for which patent applications have been made. A graduate of Ohio State University, in mechanical engineering, he was associated with Buckeye Pipe Line Co. and Ohio Fuel Gas Co. before joining Sohio.

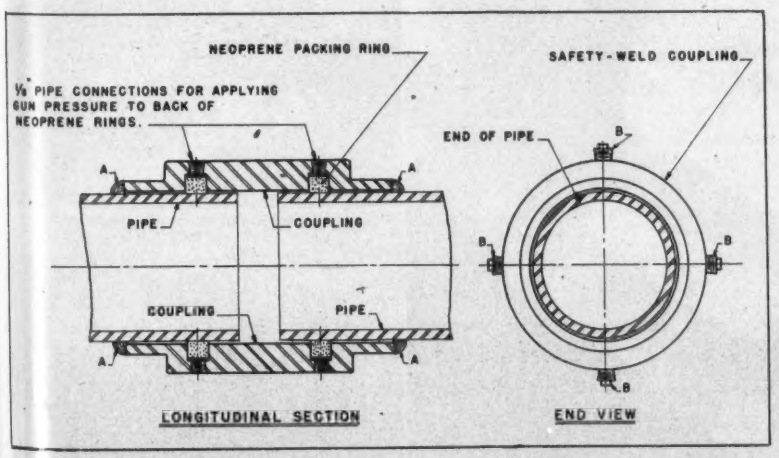
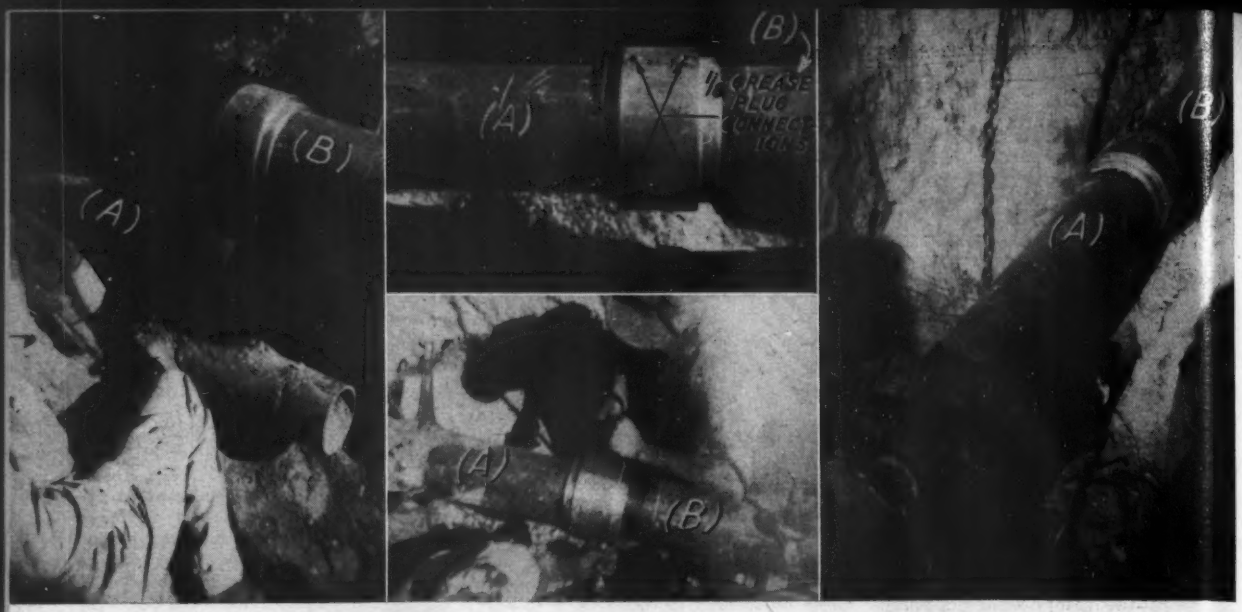


Fig. 1—Diagram indicating working principle of safety-weld coupling. Note: "A" indicates welds which are made after packing rings have been tightened and pipe line repressured. "B" indicates ⅛-in. steel pipe plugs at openings for pressure-gun connections. These can be welded at end of job if desired

The step-by-step procedure of installing a safety-weld coupling is shown in Figs. 2 to 9. These pictures were taken when the first pair of the couplings was installed on a 100-ft. section replacement in a 6-in. gasoline pipe line of Standard Oil Co. of Ohio in the vicinity of Cleveland in October 1946.

In Fig. 2 the start of the job is shown. The coupling has been pushed over the end of Section B. The left end of the coupling is even with the end of the pipe.

In Fig. 3 sections A and B are now joined by the coupling. The pipe ends were aligned and the coupling was moved back one-half of its length onto A. Notice the chalk mark on Section B which was made for accurate checking of the distance moved by the coupling. Next step is to apply



Successive stages of installing safety-weld coupling: Fig. 2—(Left) Coupling has been pushed over end of Section B; left end of coupling is even with end of pipe. Fig. 3—(Upper center) and Fig. 4 (Lower center) Pressure gun is used; the ⅛-in. pipe plugs are removed. Fig. 5—(Right) Coupling after it has been sealed; it is now pressure tight

lubricant pressure behind the packing rings.

In Fig. 4 the pressure gun is shown in use. The ⅛-in. pipe plugs are removed. These plug connections are indicated as B in Fig. 1 and they are also indicated by arrows in the photograph of Fig. 3.

Lubricant is forced into each hole until (1) it starts to come out of an adjacent hole or (2) the packing ring starts to bulge into an adjacent hole. At the high gun pressures used the packing rings flow in a manner similar to the stiff lubricant.

As soon as flow appears at the next ⅛-in. hole as noted, the pressure gun is removed and a ⅛-in. plug is started (but not tightened) into the hole in its place. After the gun has been connected to all holes, all ⅛-in. plugs are set up as tightly as possible.

The design of the coupling grooves and packing rings and the stiffness of the lubricant used make it possible to disconnect the pressure gun and then insert a ⅛-in. pipe plug without appreciable loss of pressure from behing the packing rings. The packing ring acts like a check valve and snaps shut against the ⅛-in. holes as soon as the gun connection is removed, preventing the lubricant from escaping.

Fig. 5 shows the coupling after it has been sealed. It is now pressure tight.

(Continued on page 240)

Fig. 10—Safety weld coupling

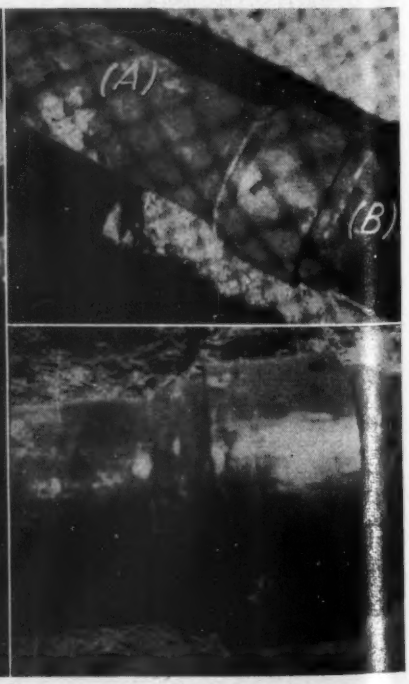


Fig. 6—(Left) Chains placed around A and B, held together by 5-ton chain hoist. Fig. 7—(Center) Stringer beads completed around each end of coupling. Figs. 8 and 9—(Right top and bottom) Welded joint completed

Industry Moving to Meet New Geographical Demand Shifts

by R. B. Tuttle

DRASTIC measures are being taken to meet a postwar shift in the crude-oil-market situation, particularly as it affects the St. Louis and Chicago refining centers which are facing unusual increases in demands for petroleum products.

Because of the significance of projects to be built soon to serve District 2 (Great Lakes states) data are presented here showing the present status of pipe-line capacities, with a forecast of capacities to be achieved by construction which will be carried on in the next 3 years.

The largest-capacity increase in products lines to any one point within District 2 is that of the combined systems serving Omaha areas. As a whole, the product-line capacity contemplated for service by 1951 in District 2, is expected to be increased substantially over current averages. Line capacities in interdistrict service apparently will not be increased by appreciable amounts, if any. Figures on current average capacities on product lines connecting with adjacent districts show that ratings on the incoming systems are more than 10 times greater than that outgoing.

The entire expansion program as now set up for increasing crude-oil pipe lines into and within District 2 is expected to run into costs upwards of one-quarter billion dollars.

Several of the companies operating pipe lines into Chicago and St. Louis areas have announced capacity increases to their facilities serving these regions. The four major companies now transporting crude into the St. Louis area have a combined total pipe-line capacity, on a nominal basis, of 296,500 bbl. per day. Pipe lines operated by three companies and serving the Chicago area are rated currently at 363,000 bbl. per day.

Crude pipe-line capacity increases into the St. Louis region, now authorized, are expected to boost current capacities upwards of 194,000 bbl. per day. Increases in capacities for all carriers serving Chicago areas will be run in the order of some 104,000 bbl. per day when all expansions currently authorized are placed in service to the area. Indications are that some of the capacity increase into St. Louis may be made available for crude-oil shipments beyond that area, as for example, southeastern Illinois refinery points, and even those within the region of Chicago.

TABLE 1—DISTRICT 2 CRUDE-OIL LINES

Areas served and carrier—	Daily capacity, annual average basis: Actual bbl. per day 1947	Estimated bbl. per day 1951
Chicago:		
Sinclair	95,000	95,000
Stanolind	139,000	206,300
Texas-Empire	129,000	165,000
Total	363,000	466,300
Cincinnati:		
Gulf	27,000	27,000
Ohio Oil Co.	9,900	9,900
Total	36,900	36,900
Cleveland:		
Buckeye	46,500	46,500
Ohio Oil Co.	8,000	8,000
Total	54,500	54,500
Detroit:		
Transit & St'ge. Co.	42,000	45,000
Buckeye	35,800	35,800
Total	77,800	77,800
Kansas City:		
Sinclair	16,000	16,000
Stanolind	29,500	49,800
Standish	32,000	35,000
Total	77,500	101,800
Lima:		
Buckeye	78,800	78,800
Magnolia	42,000	42,000
Ohio Oil Co.	174,000	174,000
Sohio	72,000	72,000
Total	366,800	366,800
Ponca City:		
Continental	50,000	50,000
Empire	36,000	36,000
Total	86,000	86,000
St. Louis:		
Ajax	80,000	80,000
Magnolia	.....	38,000
Sinclair	77,000	77,000
Shell	81,500	81,500
Stanolind	58,000	63,500
Texas-Shell	.....	150,000
Total	296,500	490,000
Toledo:		
Buckeye	152,200	152,200
Sohio	20,000	20,000
Total	172,200	172,200
Tulsa:		
The Texas Co.	35,760	31,760
Mid-Continent	36,000	36,000
Total	71,760	67,760
Southeastern Ill.:		
Texas	48,000	48,000
Texas-Empire	12,000	28,600
Total	60,000	76,600

TABLE 2—DISTRICT 2 CRUDE-OIL LINE CONNECTIONS

Incoming from: and carrier—	Daily capacity, annual average basis: Actual bbl. per day 1947	Estimated bbl. per day 1951
District 3:		
Gulf	42,000	42,000
Interstate	40,000	40,000
Magnolia	.....	100,000
Magnolia	57,000	.....
Shell	47,800	47,800
Sinclair	68,000	68,000
Stanolind	82,300	82,300
Stanolind	86,000	126,000
Texas	36,800	36,800
Texas-Cities Service-Shell-Sinclair	.....	191,000
Total	459,900	633,900
District 4:		
Stanolind	29,200	39,000
Total	29,200	39,000
Outgoing to—		
District 1:		
Buckeye	19,150	19,150
Buckeye	57,000	57,000
Ohio Oil Co.	30,000	30,000
Total	106,150	106,150
District 3:		
Magnolia	.....	55,000
Total	.....	55,000

Refining capacity in the St. Louis area, according to late reports, is in the range of 160,000 bbl. per day, at this time. By the end of 1951 or sooner, this capacity is expected to be increased upwards of 180,000 bbl. total for the district. Refineries in southeastern Illinois and adjacent areas in Indiana are rated currently at slightly more than 50,000 bbl. capacity. By the end of the next few years the 50,000-bbl. figure for these refineries may be increased sufficiently to bring the total refinery demand in St. Louis and Illinois-Indiana areas within the quarter-million-barrel mark.

Chicago-area refineries currently have a combined crude-oil charging capacity of 340,000 bbl. per day on a nominal basis. Expansion programs authorized and scheduled for completion by the end of 1950 are expected to place refinery demands in this area into the 400,000 bbl. per day bracket.

Nominal capacities of refineries in Ohio plus one in northern Kentucky, at current figures, total 232,000 bbl. per day. Refinery expansion scheduled for the plants in this area may increase the current capacity figure to 250,000 bbl. daily basis by 1951.

The total probable demand for crude oil by refineries in the northeastern section of the Middle West, because of expanded capacity, may approach closely 1,000,000 bbl. per day by early 1951.

Currently nominal capacity of pipe lines serving Tulsa and Kansas City refining areas is reported at approximately 150,000 bbl. daily. Estimated nominal capacities for 1951 on lines serving these areas runs slightly below 163,000 bbl. per day.

Piping, vessels, furnaces, valves . . . *check, check, check.* Find the weaknesses, the points of possible failure, the factors that rob a refinery of top efficiency.

CHECK - CHECK - CHECK

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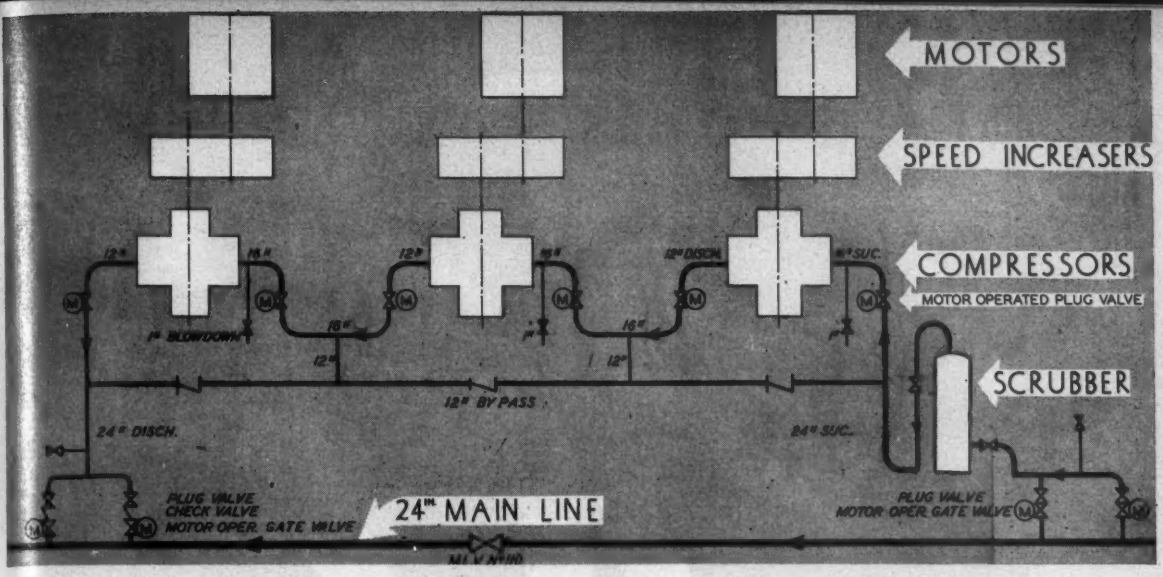


Plan for Tennessee Gas Transmission Co.'s first centrifugal compressor station, powered with three 2,000-hp. electric motors, now being built at Morehead, Ky.

Centrifugal Compressors Will Handle 350 Million Feet Per Day at New T.G.T. Station

CONSTRUCTION operations are now in progress on an electric-motor-driven centrifugal-compressor station near Morehead, Ky., on Tennessee Gas Transmission Co.'s 24-in. pipe line. The installation will consist of three 3,600 r.p.m. single-stage centrifugal compressors operated in series with each compressor being driven through a stepup gear by a 900-r.p.m. squirrel-cage induction motor. It is expected that the capacity of the station will be approximately 350,000 M.c.f. daily with a suction of 600 psig. and discharge of 750 psig. The station will be three-stage operation with the entire gas stream passing through each compressor unit.

This centrifugal compressor station will be the first pipe-line installation for pressures of the magnitude of 750 lb. and where the design does not contemplate the use of some station facilities already in place. A pioneering installation of a centrifugal compressor in a gas-transmission line operating at about 500 psig. was made as early as 1931 near El Dorado, Kans. Texas Eastern Transmission Co. proposes to install centrifugal compressors in some of the existing pumping stations on the "Inch" lines, and it is reported that one station with centrifugal compressors will be put in operation in September or October 1947.

The Tennessee Gas Transmission Co. station will be installed about midway between two existing compressor stations, No. 13 and No. 14, located near Winchester and Catlettsburg, Ky., respectively. It is expected that the centrifugal-compressor station will substantially increase gas deliveries to the Appalachian area during the coming winter season. It is reported that if this type of compressor proves completely successful, it is possible that additional stations using centrifugal units may be constructed by Tennessee Gas Transmission Co. provided electric power can be purchased at favorable rates.

The station will be built at a main-line valve and "hot" taps made to allow it to be put in service without interrupting the movement of gas in the main line.

Cost of Station

It is estimated that this station will cost about $500,000, which amount is materially less than the normal cost of a conventional reciprocating unit station. Aside from the cost of electric power, it is expected that the centrifugal-type compressor station can be operated and maintained at a substantially lower cost than a conventional compressor station. Electric power for the station will be obtained from the transmission system of Kentucky & West Virginia Power Co. at 33,000 volts, a substation at the plant site will step down to 4,100 volts for the 2,000 hp. motors.

The plant design has incorporated recognized safety features commonly used in electric motor operated pumping stations on crude and products pipe lines, and automatic devices have been provided in every case where their use appears practical.

Operation of the plant will be controlled from a central control panel located in one end of the compressor building. The starting and stopping of all motors and the operation of electric-power-driven valves will be handled from this point. Alarm lights on all automatic shutdown devices will also be mounted on this board. All instruments, control switches, warning lights, etc. on the panel will be explosionproof.

The plant switch gear will be installed in a separate building located some distance from the compressor building. This building will also house certain auxiliary equipment and, in addition, will provide space for a change room. The plant substation will be located approximately 200 ft. from the compressor building and about 300 ft. from the 24-in. main line.

While the gas turbine is attractive from a purely mechanical standpoint as a prime mover for centrifugal compressors, the metallurgical requirements seem to present problems which may not be solved for some time.

The centrifugal compressor driven by electric power has been used in the steel and coke industries sufficiently to demonstrate that it is beyond the experimental stage. For natural-gas pipe lines it appears to offer possibilities where electric power may be purchased advantageously.

30" Completed!

The "BIGGEST INCH"

Completed ahead of schedule, we take pride in our record as constructors of this huge project—the "Biggest Inch" section of the Texas to California pipe line. The completion of this first 30-inch high-pressure natural gas transmission pipe line marks another epoch in the progressive history of the pipe line industry.

PIPE LINE CONSTRUCTORS

H. C. PRICE CO.

Bartlesville, Okla. Portland, Oregon

Handling a section of 18-in. pipe at part of route which traverses an orchard near Antioch, on San Joaquin Valley pipe line

California Standard's 18-In. San Joaquin Line Shipping 125,000 Bbl. Crude Daily

ONE year after completion, Standard Oil Co. of California's 18-in. San Joaquin Valley pipe line is carrying an average of 125,000 bbl. per day to meet an increased demand for crude stocks at refineries in the San Francisco Bay area.

The 176-mile light-oil line, put into operation on July 7, 1946, was originally designed to carry an estimated 85,000 bbl. daily. At the time of completion this capacity had been increased to 110,000 bbl. per day by addition of a booster pump station near Los Banos, a point approximately midway between Kettleman station and Los Medanos tank farm, southern and northern terminals of the new line.

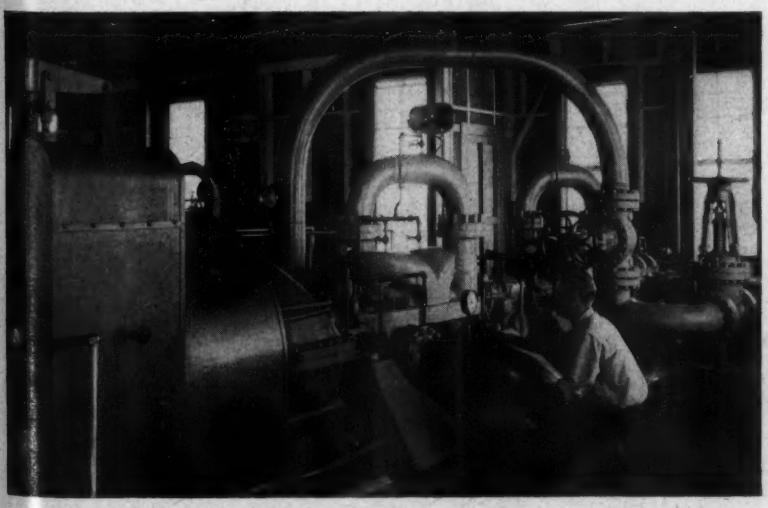
Early this year, after 6 months of operation the line's capacity was further increased to its present volume to meet additional crude-stock demands. This was accomplished by adding a third booster pump to the two centrifugal-type, 800-hp. electric-motor-driven units originally located at Los Banos.

Installation of this third pump enabled the booster station output to be increased to the maximum allowable pressure, 900 psi., the same pressure under which the crude is started northward from Kettleman station.

Provision was made at the time of construction for the possibility of increasing pumping pressures when special high-strength pipe was laid for 41 miles north of Kettleman station. This A. O. Smith pipe has a yield strength of 52,000 psi. or an ultimate tensile strength of 72,000 psi. Other 18-in. pipe in the line has a yield strength of 45,000 psi.

With the exception of 9 miles of 20-in. reclaimed from a feeder connection to the Stanpac line, the line consists of electric-welded pipe of ¼-in. wall thickness, having extra high yield points produced by a hydraulic expanding process at the mills.

No major breaks or leaks have occurred in the line, the only loss of oil experienced being through a small pit hole in one section of the reclaimed 20-in. pipe which was evidently overlooked at the time of reconditioning.



Steam-turbine-driven centrifugal pumps at initial station on 18-in. line

Coating of Line

One hundred miles of the line is coated with Somastic, while protection for the remainder has been achieved with asphalt and fabric wrapping.

Light crudes handled in the 18-in. line vary from 22° to 36° gravity, and average about 30° gravity. The waxy stocks range from 30° to 36°, while the asphaltic-base oil is usually of 26°-27° gravity.

The line is operated on an 8-day cycle, handling one batch of each of these crudes during this period. The waxy batches are usually of 600,000 to 700,000 bbl., the asphaltic-base stock batches average between 250,000 and 300,000 bbl. Volume of the line is 281,000 bbl.

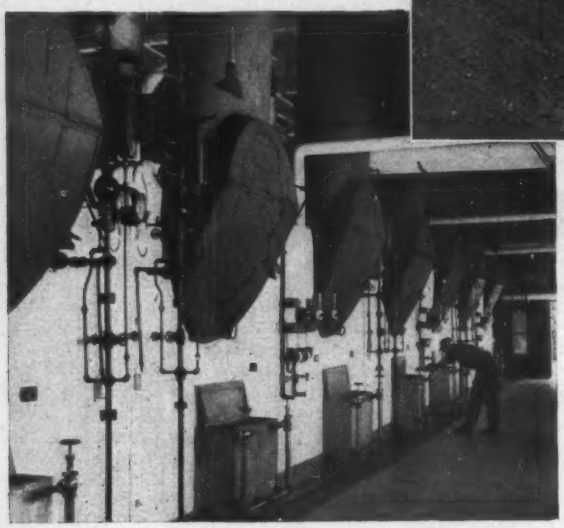
Crude is gathered from Kettleman Hills, Coalinga, and other San Joaquin Valley fields. About 75,000 bbl. per day is put into the line from

Kettleman station, and about 50,000 bbl. per day is pumped into the line 25 miles north of Kettleman from a station at Coalinga.

Steam-turbine-driven centrifugal pumps are used at the Kettleman station, while at Coalinga the oil is moved with electric motor-driven pumps similar to those at the Los Banos booster station.

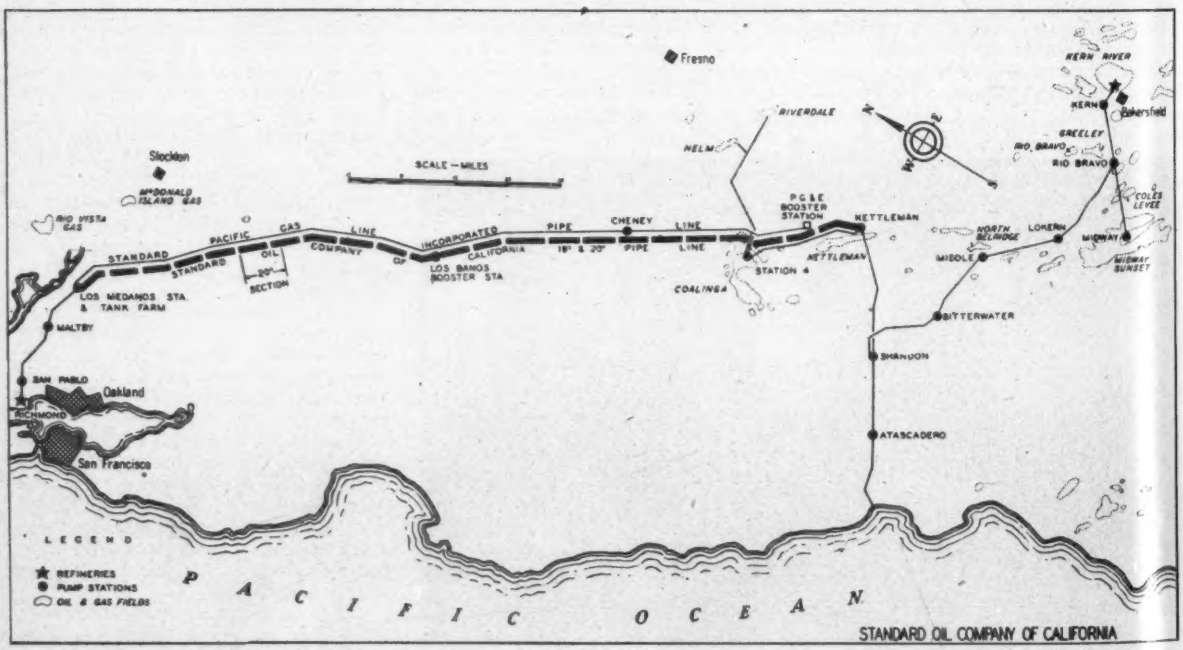
During the first year of operation the line has been scraped about once a month, but it is expected that the interval between scrapings soon will be lengthened if no impediments to the oil flow are experienced. So far no appreciable amount of wax has been found in the line.

Because it was constructed over favorable terrain for most of its distance, the line is easily patrolled by driving along the right-of-way. Another check maintained on possible breaks or leaks is a recording flow meter at the Los Banos station which telemeters flow readings to the Los Medanos terminus and to Coalinga pumping station. Any appreciable difference between the amount of oil passing through the booster station and the amount being discharged at Los Medanos or pumped into the line at Coalinga indicates immediately the oil being lost through a break. In addition to this, positive-displacement meters are in operation at both ends of the line.

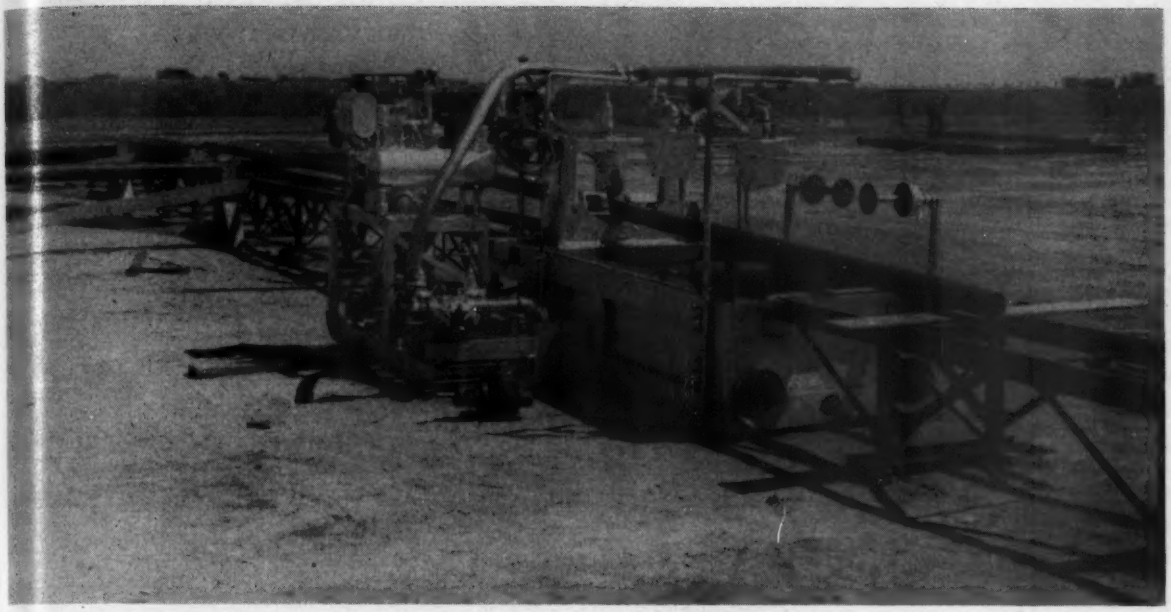


Above: Lowering in 18-in. pipe on the San Joaquin Valley pipe line

Left: Boilers at initial station of the San Joaquin Valley 18-in. pipe line



Map of Standard Oil Co. of California's 18-20-in. pipe line, San Joaquin Valley to San Francisco Bay



Stationary pipe-coating machine operating at a yard located at the Denver terminal from which protected pipe is delivered to right-of-way

Wyco Products Pipe-Line System Is Designed for Rocky Mountain Service

THE first extensive products pipe line to be laid in the Rocky Mountains is now under construction for Wyco Pipe Line Co. Early this year expenditures for the project were finally authorized for the undertaking after considerable preliminary study, begun in 1943, had been carried on. Execution was delayed during war years.

In September 1946, estimates of volumes were prepared, preliminary batching schedules were devised, and many engineering details were agreed upon including the decision to use the electric - motor - driven, reciprocating, constant and variable-stroke pumps for the main-line station, which are a distinctive feature of the project. Two additional automatic pump stations were considered for future construction to give a total ultimate capacity of 30,000 bbl. daily.

Cleaning machine is ahead in distance; coating and wrapping operations are in foreground

The entire line of 267.7 miles consists of 7.3 miles of 6-in. (Casper station to Strouds station); 169.7 miles of 8-in. (Strouds station-Cheyenne terminal); 90.7 miles of 8-in. (Cheyenne to Denver terminal).

The 8-in. line from the Casper station is 22.36 and 24.70-lb.-per-ft., Grade B seamless steel pipe; 43.39-lb.-per-ft. pipe is used at river crossings. The 7.3 miles of 6-in. pipe to the Strouds station is made up of miscellaneous weights of pipe purchased where available, as delivery on the total could not be had.

Protective Coating

The line is protected for its entire length by a composite coating consisting of a double-coal-tar coat and a double wrap of glass fiber and asbestos felt.

The topography of the terrain is such that the beginning and end of the line are at the same elevation of 5,100 ft. The high point near Cheyenne is 6,400 ft.; from this point it is almost possible for products to gravitate from Cheyenne to Denver.

The pipe line itself runs north from Casper across the North Platte River, thence due east, again crossing the

North Platte River and passing south of Glenrock. The pipe line then runs southeast passing west of Douglas and Glendo. From there the line runs almost due south to Denver. An aerial survey was made in 1943.

Laying of the line has been contracted as follows: Job 1: Allred-Enix Construction Co., 7.3 miles, 6-in. and 132.8 miles 8-in. running south from Casper. Job 2: Pacific Pipe Line Engineers, Ltd., 127.6 miles, 8-in., north of Denver. Hauling and stringing was contracted by J. L. Cox & Son and Tom Weadlick.

Pumping equipment for the project has unusual features. At the initial point known as Casper booster station, there will be two 100-hp. electric motors driving vertical, centrifugal pumps, mounted in the open, (not in a pump house of any kind) and located on land leased from the Standard Oil Co. (Ind.) Casper refinery.

The main pump station at Strouds, which will move products for the entire project, will have one 0-6-in. variable-stroke Groff triplex Aldrich pump and three 6-in. constant-stroke Aldrich triplex pumps. All of these will be driven by 100-hp. electric motors.

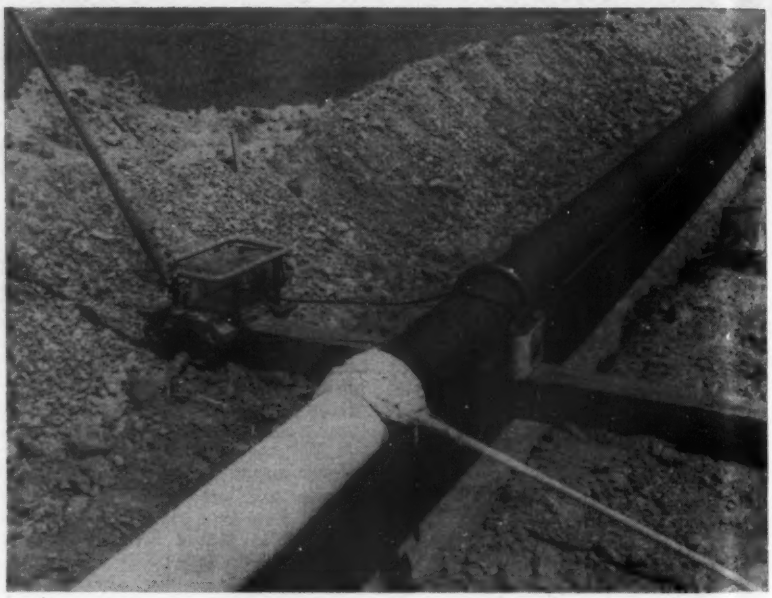
Particular attention has been given in designing the station building so that it would be consistent with modern, western architecture. The building is to be about 40 by 70 ft.; it will be constructed of brick and tile. The only tankage at the station will be two 2,000-bbl. spill tanks.

A maintenance building will be constructed at Wheatland, Wyo., where maintenance trucks and work equipment will be stationed. If required later, an additional building will be built at Greeley, Colo.

Along the line, six 8-in. corrosion spools with block gates at each end will be installed. These can be removed for periodic inspection to investigate internal corrosion without causing prolonged shutdown periods.

Map of route to Wyco system. Figures to the left of the line indicate the rate at which estimated annual daily average deliveries will be made in 1951: 19,400 bbl. to the Cheyenne, Wyo., terminal; 12,900 bbl. to Denver

Coating and wrapping machine served by large modern dope kettle



Holiday detector for testing coating and wrapping of entire Wyco system

Block gates will be located at strategic positions along the line, approximately 15 miles apart. These valves are used for minimizing product losses in case of a leak. These also aid in locating a leak in the line.

Test connections are being installed at 1-mile intervals along the pipe line to facilitate corrosion surveys and the eventual installation of cathodic protection. Internal corrosion will be mitigated by use of Sand Banum inhibitor at beginning of operations.

The Cheyenne terminal, southwest of the city, adjacent to the Colorado & Southern Railroad, will have eight floating-roof tanks and eight cone-roofed tanks. A double-island transport dock and a 28-car loading rack are to be built.

Notable innovations in loading equipment are the stuffing-boxless pumps located at the tanks. These can be controlled from both the racks and the docks. The minimum size transport trucks to be loaded by Wyco will be of 3,000 gal. capacity.

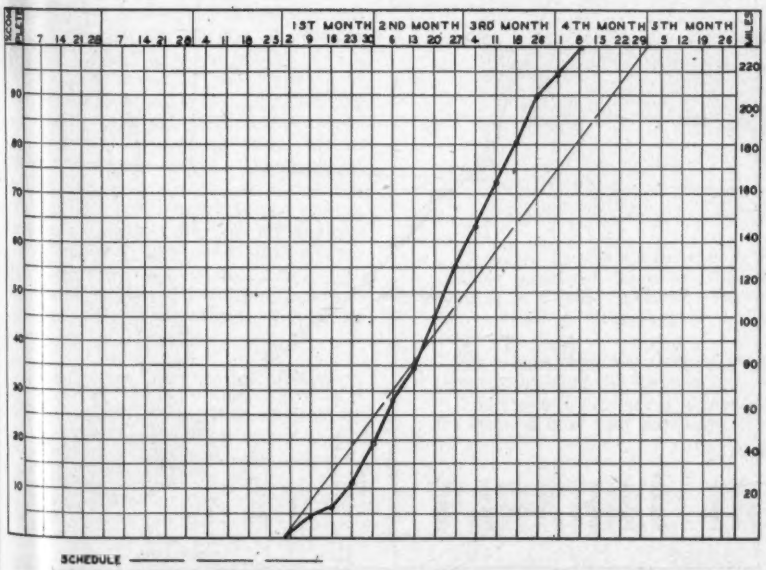
The Denver terminal, north of the city between the Union Pacific Railroad and U. S. Highway 85, will have seven floating-roof tanks and eight cone-roof tanks. Pumps and loading facilities will be similar to those at Cheyenne where there will be a double-island transport dock and a 36-car loading rack.

Construction of the two pump stations has been contracted by Brown Lane Co. The two terminals are contracted by Midwestern Constructors, Inc.

Line-up crew assembling pipe through a draw

Lakin-Denver Gas-Transmission Project Scheduled for Early Completion

by Preston Parks*



Progress chart of Hugoton 20-in. line, Lakin compressor station to Denver crossover station

COLORADO INTERSTATE GAS CO. together with Canadian River Gas Co. have been operating since 1928 a 340-mile 20 and 22-in. natural-gas pipe line serving a territory between Amarillo and Denver. Flowing capacity of this line has been increased from time to time, reaching a maximum during the winter of 1946-47 of 140,000 M.c.f. per day. Studies that were completed early in 1946 clearly indicated the need for a new pipe line to Denver for service during the winter of 1947-48. Further studies resulted in a decision to proceed with this project, namely: the construction of a 20-in. high-pressure pipe line from Hugoton gas field to Denver, together with a compressor station, dehydration plant, field gathering lines, etc.

The decision to go ahead with this project was reached in April of 1946 and since it was necessary to have this project completed for the winter of 1947-48, time was one of the most vital considerations. Orders for pipe,

*Engineer, Colorado Interstate Gas Co.

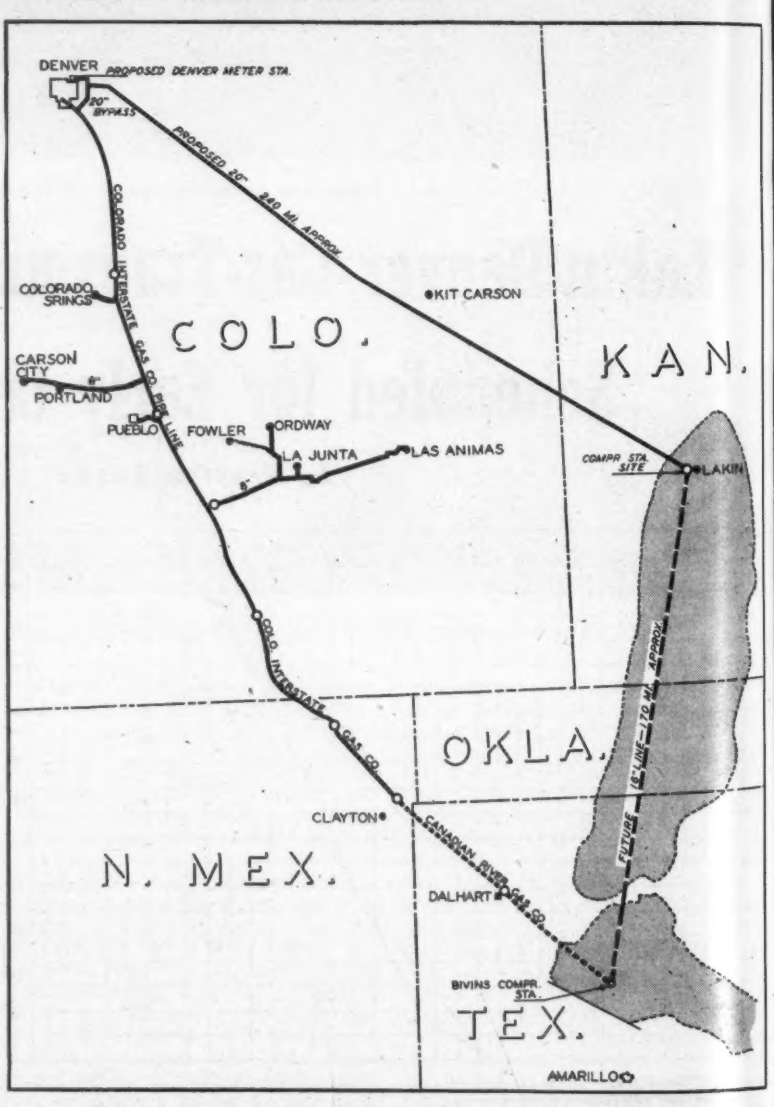
Coating and wrapping machine followed by holiday detector

compressor units, and other major materials were placed immediately. Contracts were awarded covering the detailed design and construction of the pipe line, compressor station, dehydration plant, field lines, etc. Gas-purchase contracts were signed with producers in Hugoton field. Approval of this project by the Federal Power Commission was granted on May 23, 1947, and as a result of previous planning, pipe and other materials were on hand, the construction equipment and personnel were in the field, and construction of the pipe line and compressor station started immediately.

Hugoton gas field rather than Panhandle field was chosen as a source of supply because:

1. It is nearer to Denver, requiring less pipe, an important consideration when pipe is so difficult to obtain.
2. The location is far better pipeline country, allowing some saving in construction costs.
3. It afforded an advantage in that it increased connected gas reserves.
4. It serves to insure the Denver and other market areas against possible interruption of service due to washouts. Localized heavy rainfall along the Panhandle-to-Denver pipe line has caused pipe-line washouts at quite unexpected points. Choosing a location for the new pipe line at a considerable distance from the present one prevented exposure of both lines to the possibility of washouts from the same flash flood.

For reasons of desirable future flowing capacities and giving consideration to other economic aspects and materials that were available, the pipe selected for this line was 20-in. o.d. by 5/16-in. wall thickness, electric welded suitable for operating pressures of 900 psig. The pipe line is approximately 230 miles in length from the field compressor station to a crossover station just east of Den-



Map showing proposed routes of natural-gas pipe lines from Hugoton

ver. From this crossover station the pipe continues for 20 miles to meter stations on both the north and south sides of the city. The pipe line is of welded construction throughout its entire length; 20-in. main-line plug-valve assemblies are welded into the pipe line at approximately 10-mile intervals. All of the pipe is protected with one coat of primer, a coat (3/32-in.) of coal-tar pipe-line enamel and is wrapped with either asbestos felt or Fibreglas.

Design of Crossover Station

The crossover station mentioned above is designed so that gas may flow through it in either direction, permitting gas from the Hugoton line to flow to the south Denver meter station, or permitting gas from the Panhandle line to flow to the north Denver meter station. The direction of flow will depend upon the respective pipe-line pressures and will be automatic in operation.

This pipe line will have an initial flowing capacity of 100,000 M.c.f. per day and an ultimate flowing capacity of 236,000 M.c.f. per day. Engineering supervision of the construction and design of this line is being performed by Ford, Bacon & Davis Construction Corp. of New York. Actual construction of the 230 miles of 20-in. pipe line by J. R. Horrigan Construction Co. of Houston was completed in 120 days' elapsed time from start to finish. Two complete spreads were in the field and the line was laid at an over-all rate of approximately 2 miles per day.

The compressor station at Lakin, Kans., was designed and is being constructed by Stearns-Roger Manufacturing Co. of Denver. Plans call for the installation of seven 1,200-hp. angle-type single-stage compressors. The compressors will be operated at a suction pressure of 225 psig. Considering one unit as a spare the station will deliver 100,000 M.c.f. per day at a discharge pressure of 710 psig. Other units at the compressor station include an auxiliary building with three 410 hp. gas-engine-driven generators, a machine shop, warehouse, garage, office, atmospheric cooling tower with coil shed for gas cooling and cold jacket water circuit, fin-fan cooling unit for hot-jacket-water circuit, and other miscellaneous equipment and buildings. All pipe and equipment at the station is designed for maximum operating pressures of 900 psig.

Design of Dehydration Plant

The dehydration plant located on the Lakin compressor station site was also designed and is being constructed by Stearns-Roger. The plant is a two-unit Fluorite-type dehydration process. Each unit will be alternately on the line for a period of 8 hours and then regenerated. The plant is designed for maximum working pressures of 900 psig. Other major construction at the Lakin site includes a village consisting of 20 residences and a boarding house which is being built by Abrahamson Construction Co. of Colorado Springs.

Approximately 170 miles of gathering lines ranging in pipe sizes from 4 to 20 in. are being constructed by Midwestern Constructors. Approximately 100 wells are to be connected for service during the winter of 1947-48. In all cases gas is metered and purchased at the well head.

Communication facilities will include a telephone line, fixed and mobile radio units, and telemetering. The telephone line will as nearly as possible parallel the pipe line and will be connected to present telephone facilities at Denver. A fixed radio station will be located at the Lakin compressor station site and several mobile units will be installed in company automobiles. Line pressures at Lakin and pressures and deliveries at Denver will be telemetered and recorded at the company's Colorado Springs office.

This entire project is scheduled for completion by October 1, 1947, at a cost of about $12,500,000. Considering the scarcity of materials and the time element involved a great deal of credit is due to everyone concerned with completing this project.

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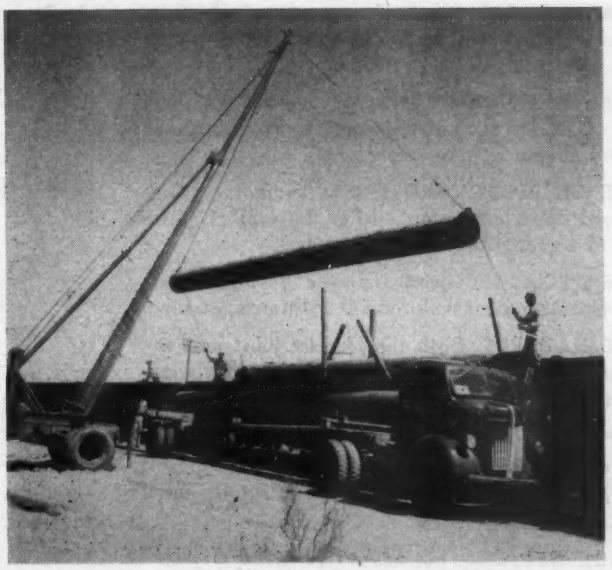

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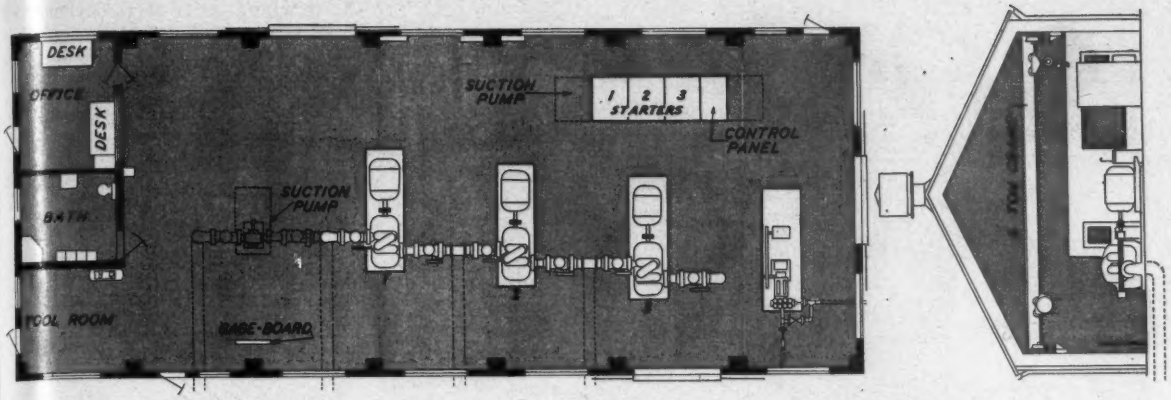


Plan and side elevation of main electric centrifugal pump stations at Foreman and Conway, Ark., and Doniphan, Mo., for Magnolia Pipe Line Co.'s Corsicana, Tex.-Patoka, Ill., crude-oil line now under construction

Magnolia's Electric Centrifugal Pump Stations Designed for 20-In. Crude-Oil Line

FOR the 647-mile 20-in. crude-oil pipe line from Corsicana, Tex., to Patoka, Ill., Magnolia Pipe Line Co. is in the process of building four electric centrifugal stations for initial operation. In planning for the whole project, the company is providing for adding four more stations in the future which will eventually give a total of eight stations.

Information on some of the principal features of station design presented on this article was procured with the assistance of Lester H. True, vice president and manager; John G. Norton, chief mechanical engineer; and Stanley Westlake, assistant chief engineer, Magnolia Pipe Line Co.

The stations have been planned so that additional facilities may be economically installed later for handling larger throughputs. Although the immediate shipments to be made soon after completion in February 1948 may be approximately 80,000 bbl. daily, the initial rating of the line is regarded as 102,000 bbl. daily.

The four stations being provided this year will be equipped identically. Each station will have three two-stage Bingham pumps in series directly driven at 3,550 r.p.m. by a 900-hp. General Electric squirrel-cage induction motor. Pumps are 10 by 12 in. double volute, with double suction. Early operation calls for using two units at a time; the third unit is to be a spare. Initial operating pressure is to be 700 psig.

Although motors with less horsepower would be ample to handle the immediate demand of 80,000 bbl. daily, the station pumping units are equipped with 900-hp. motors which will be capable of handling up to 127,000 bbl. daily, when intermediate station pumping units are installed. This latter would be at a later period when demand warrants expanding the facilities. Each of these intermediate station units will operate with a discharge pressure of 350 psig. Throughput may be increased still later to 152,000 bbl. daily by replacing the 900-hp. motors with motors of a larger size. Even in this case the same pumps will continue to be used, by merely making impellor changes. This last arrangement would involve operating the eight stations at 700 psi.

Control Valve

On the discharge side of each station there will be installed a pressure-volume control valve which will control flow conditions by means of discharge and suction pressures.

Operations will be further safeguarded by three Mercoid switches on each unit. These switches will function as follows: (1) excessive temperature of stator on motor windings will give a signal; (2) by means of a bulb in the motor oil, excessive bearing temperature will shut down the unit; (3) excessive low suction and high discharge pressures will lead to the shut down of individual pumping units.

Motors and lighting will be controlled from explosionproof panels in the pump room. Pumps will be equipped with Crane mechanical seals. Motors will have forced-feed lubrication.

A suction pump may be installed at some later date to supply as a booster to the main units capable of providing approximately 20 - 30 lb. positive suction pressure.

As a consequence of long successful experience in operating electric centrifugal stations without fire walls, Magnolia Pipe Line Co. is not using fire walls for its big-inch project. Since the time when the first electric centrifugal station of the company was built in 1924 at Westbury, Tex., near Beaumont, there has never been a fire at any company station of such a type.

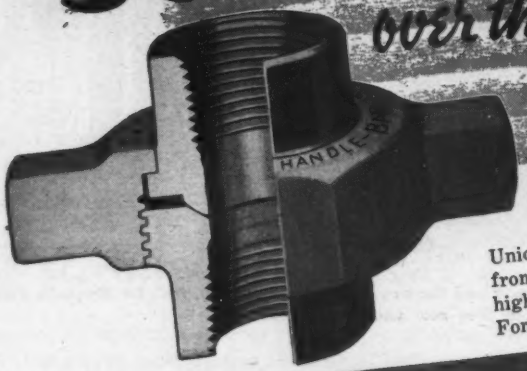
The 20-in. main line is of ½-in. wall thickness on the discharge sides of the stations at Foreman, Ark., Conway, Ark., and Doniphan, Mo. Manifold piping connecting the units at the station is 16-in pipe. The remainder of this 20-in. main line is pipe of ⅜-in. wall thickness for a distance of 6 miles.

There are two 16-in. and two 20-in. Walworth motor-operated carbon molydbenum steel valves on piping outside the station building which are controlled from a panel located outside the station protected by a shed-roof shelter.

Incoming and outgoing scraper traps are provided at each station. All valves between pumps are 800-psi., 12-in. Merco plug valves. There are suction strainers on the incoming stream. At the Corsicana, Foreman, Conway, Doniphan, and Patoka stations, scraper traps will be installed. At intermediate stations, to be built in the future, there will be strainers but not traps.

While the stations at Foreman, Conway, and Doniphan will be built according to the same general plan,

Service over the gears with FORGED STEEL UNIONS



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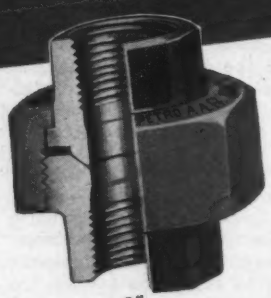
Petro



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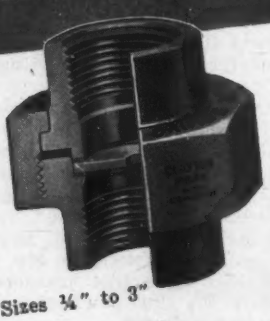

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the pumping units at Corsicana will be placed in a corner of the existing brick station building. To make room for the three electric centrifugal units, some old diesel-engine-driven reciprocating units have been removed from the Corsicana station.

Main station buildings are each 99 by 39 ft. of steel construction with Transite siding and roofing.

At the end of each main pump-station building there will be three rooms:

1. Office with operator's desk facing window looking into the pump room and chief's desk at the end of the room.
2. Bathroom with hot water heaters, showers and lockers.
3. Toolroom.

In the yard there is a storeroom and a garage. The substation is 100 ft. from the main station building. Communication for the line will be by telephone system operated by the Magnolia Pipe Line Co.

There will be no tankage installed along the line from Corsicana to Patoka. Corsicana tank farm will have four new 120,000-bbl. floating-roof tanks now under construction for sour-crude storage service plus cone-roof tanks for sweet-crude service.

At the Corsicana tank farm a 10 by 12-in. single-stage double suction centrifugal pump for handling full volume at 30 psi. will be installed to insure adequate flow to the main-line centrifugal pumps.

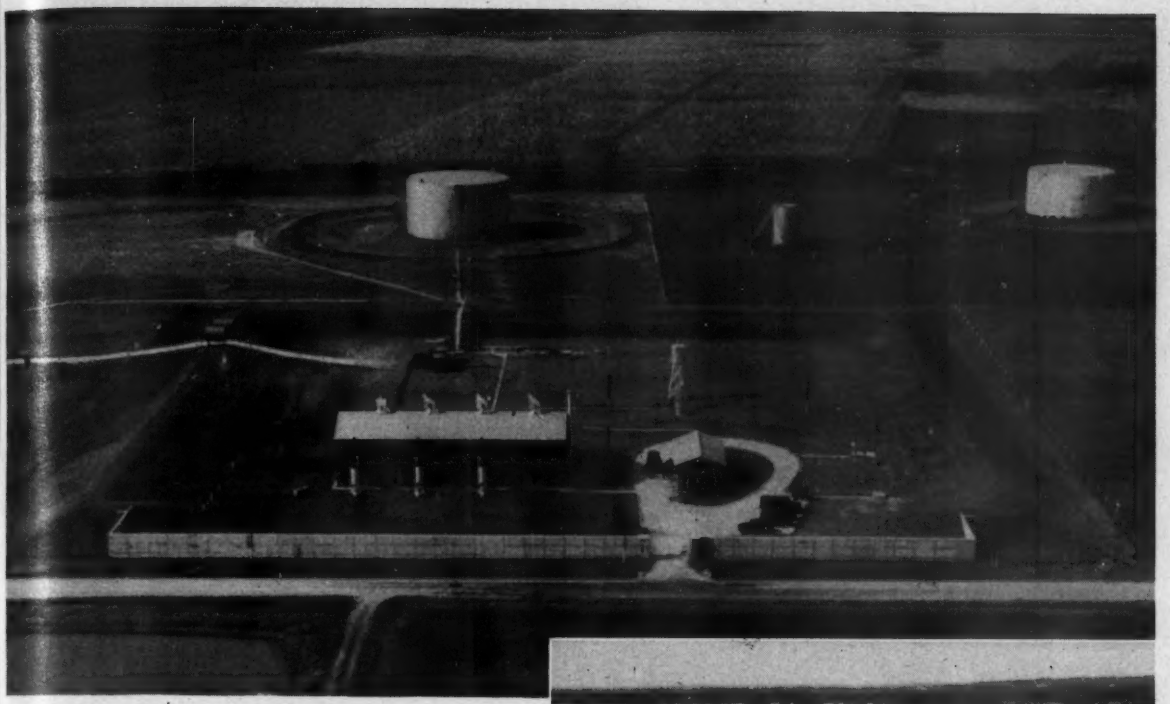
Eleven new tanks are being built at Patoka which include five cone-roof 80,000-bbl. tanks, four 80,000-bbl. double-deck floating-roof tanks, and two 120,000-bbl. pontoon-type tanks.

From Patoka deliveries will be made into the present 10-in. system supplying the Lubrite refinery at East St. Louis, Ill., and east through a 10-in. line to Lima, Ohio, also into other carriers for delivery to Chicago. Three additional pumping units for such shipments are being installed at Patoka, each of which will consist of a Bingham centrifugal 3,600-r.p.m. pump driven through Farrell-Birmingham stepup gears by a 540-hp., 6-cylinder, 360-r.p.m. Worthington engine.

Shipments will be handled in two kinds of batches: one for sour and the other for sweet crudes. Batches will mostly be of 150,000-200,000 bbl.

Stanford Gets Seismograph

An oil-exploration seismograph has been given to Stanford University by Shell Oil Co., Inc. The equipment, valued at from $12,000 to $13,000, will be used in the school of mineral sciences for classroom demonstrations on how the instrument is used to locate buried oil structures.



Above: The Valmeyer, Ill., pump station as viewed from a bluff immediately east of the station site. The Mississippi River runs along the base of the Missouri hills in the background, some 3½ miles away. Right: Gulf Refining Co.'s Valmeyer station completely surrounded by Mississippi River flood water during the 1947 flood

by Delbert Jones*

Special Levee System Protects Pump Station

DUE to the recurrence of floods along the Mississippi Valley, Gulf Refining Co., Tulsa Pipe Line Division, constructed a flood wall around its Valmeyer, Ill., pump station. The wall completely surrounds the station and manifold but does not include the station tanks and cottages. The flood wall consists of a dirt-fill on three sides and a concrete retaining wall along the side adjacent to the county road. Entrance to "Fort Valmeyer," as the station is frequently referred to because of resemblance of the station's levee system to early military fortifications, is by means of a gateway in the concrete wall. During a flood this gateway can be blocked by means of logs and sandbags to close completely the levee system. To handle seep water and rain water at flood times, emergency pumps have been installed. A large portable-type centrifugal pump was installed to handle a large volume of water, either in case of major break or a torrential downpour. Smaller construction-type portable water pumps are available to handle seep water.

In July 1947, these precautionary measures taken in 1945 were put to a test. The Mississippi River again flooded the station site as it did in 1943 and 1944. But unlike former floods, this time the flood wall permitted the station to operate at full capacity. This was done even while the water outside the flood wall reached a height of 4 ft. 11½ in. above the station floor at the crest of the flood. The station was completely surrounded for a period of approximately 2 weeks. Other than the necessity of checking the water pumps periodically the station routine was not seriously disrupted. The flood waters reached about halfway up the levee, enough to test its soundness and relieve any anxiety regarding seep water, etc. The occasion proved the ability of the station to operate free of vibration difficulties when entirely surrounded by water for a protracted period of time.

Even though the station is located on what appears to be a bed of quicksand and even though in dry weather some vibration is noticeable near the station building, the presence of water outside the flood wall did not ma-

*Master mechanic, Gulf Refining Co., Tulsa Pipe Line Division.

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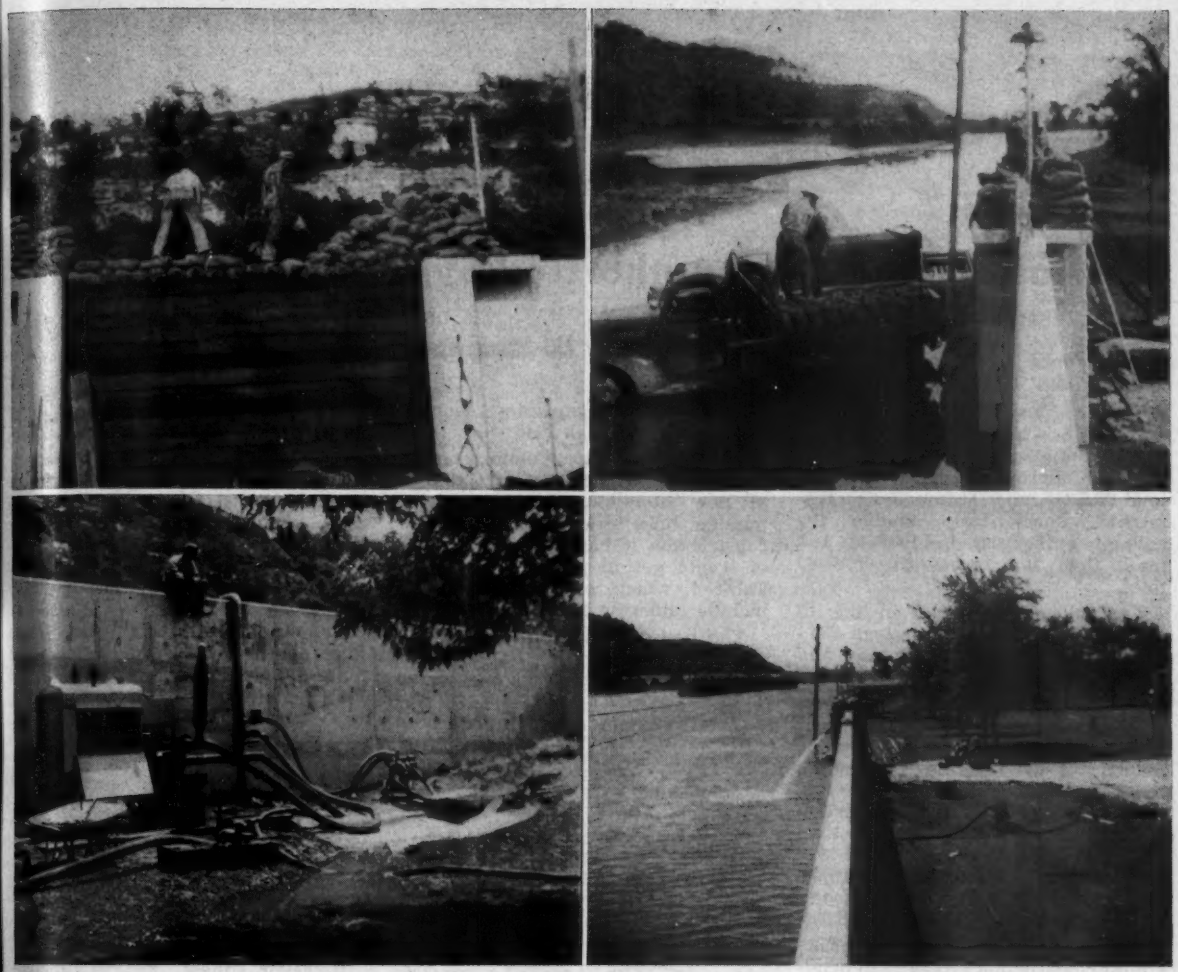
New York Washington Bradford, Pa. Parkersburg, W. Va. San Francisco, Calif. Houston, Dallas, Greggton



Top, left: Gateway in concrete wall being closed by means of logs and sand bags. Top, right: Extra bags were piled on top of gateway logs for possible emergency use. Bottom, left: Portable pumping units inside the concrete wall pumping surface water during the flood. Bottom, right: Water is 5 ft. deep outside concrete wall at the height of the flood. Here seep-water pump is in action

terially alter this situation. The soil is of such a composition that seep water did not enter the station grounds in the quantities expected. In fact, had the entrance gate been a little more carefully sandbagged, the amount of seep water would have been practically nil, leaving the actual rainfall to be the only factor to be reckoned with in the handling of surface water.

During the 1943 flood of the Mississippi River, the flood waters were allowed to enter the station building after removal of all electrical equipment. The waters reached a height of 5 ft. 6 in. above the station floor, disrupting the station operation for a period of 2 weeks. In addition to the loss in pipe-line capacity, considerable expense was involved in cleaning up the equipment after the flood.

In 1944, the Mississippi again breached the levee system when it reached a new high of 39.14 ft. on April 30. This time the station building was sandbagged and most of the water was kept out of the building. Small centrifugal water pumps were used to take care of the seep water entering the building. This procedure relieved the expense of cleaning up after the flood but did necessitate the loss of pipe-line capacity from the flood period due to the presence of water immediately outside the station building. Backwater reached a height of 4 ft. 4 in. above the station floor during this flood. The experience of these two floods influenced the decision to erect the levee system to insure continuous operation during such times.

Flood Records

The 1947 flood saw the Mississippi River rise to a 103-year record high of 40.3 ft. on July 3, slightly under the all-time high of 41.39 ft. set at St. Louis in 1844. The river levee system had been repaired after the 1943 and 1944 floods, and in addition a levee designed to withstand a flood stage of 50 ft. was in the process of construction by the U. S. Engineers. The new levee system had been completed at some points but not sufficiently along the entire course of the river to prevent the recurrence of disastrous floods along the Mississippi Valley. The Valmeyer pump station is located adjacent to the town of Valmeyer, Ill., about 30 miles south of St. Louis and approximately 3½ miles from the normal course of the river. The breaches in the Mississippi River levee system in 1944 and 1947 occurred at approximately the same point, some 2 miles west of Valmeyer.

About 4 hours was required for water from the break to reach the station grounds, the station being somewhat protected by the presence of a railroad directly west of the station. During the 1947 flood the first break occurred in the river levee below Harrisonville, Ill., 8 miles below the pump station. Back water from this break completely surrounded the pump station prior to the break in the Valmeyer levee. Inasmuch as the station is close to a high bluff and protected by the railroad on the opposite side, no trouble from river currents was experienced in any of the floods. While the pump station was continuing operation without interruption, the 1947 flood did millions of dollars damage in the Mississippi Valley area.

5369 Miles of Interstate

Natural-Gas Lines Authorized by FPC in 1946-1947

by Henry D. Ralph

FOR the fast-growing natural-gas pipe-line industry, the Federal Power Commission in the 1946-47 fiscal year approved construction of a total of 5,369 miles of interstate transmission lines—nearly double the amount authorized in 1945-46 and more than four times the 1944-45 total.

The mileage approved in the 12 months ended June 30 involved 735,230 aggregate horsepower in new and existing compressor stations and an expenditure totaling $273,190,302.

Indicative of the certain future growth of the natural-gas pipe-line industry is the fact that the federal regulatory commission now has before it applications for construction of more gas pipe-line mileage than the entire total authorized from 1943 to 1947. These pending applications involve 14,292 miles of line and compressor horsepower totaling 735,230.

The total expenditure of $768,952,478 for construction proposed in pending applications amounts to nearly 40 per cent of the total value of the gas plant of all companies reporting to the commission in 1945.

The Federal Power Commission has had jurisdiction over construction of all new interstate natural-gas transmission lines since 1942. The new construction it has authorized, much of it not yet in place, is shown in Table 1, which, of course, does not include gathering or distribution lines.

The natural-gas industry is growing so fast that it can't be measured. Strange as it seems, no one knows for certain just how many miles of natural-gas transmission lines there are in this country.

A very rough estimate would be around 100,000 miles of pipe of all sizes (including loops where two or more lines run in the same right-of-way) excluding field gathering lines and local distribution lines and city mains.

The American Gas Association gives these figures as mileage of natural-gas pipe lines in the United States:

TABLE 1—CERTIFICATES FOR NEW CONSTRUCTION ISSUED BY FEDERAL POWER COMMISSION TO INTERSTATE NATURAL-GAS COMPANIES, BY FISCAL YEARS ENDED JUNE 30

(Includes looping projects)

Year	No.	Total miles	Compressor horsepower	Estimated cost
1943	4	51	3,560	$1,642,509
1944	25	2,373	108,490	106,082,485
1945	43	1,181	66,610	34,170,760
1946	52	2,994	184,275	127,189,731
1947	132	5,369	360,349	273,190,302
(*)	77	14,292	735,230	768,952,478

*Pending June 30, 1947.

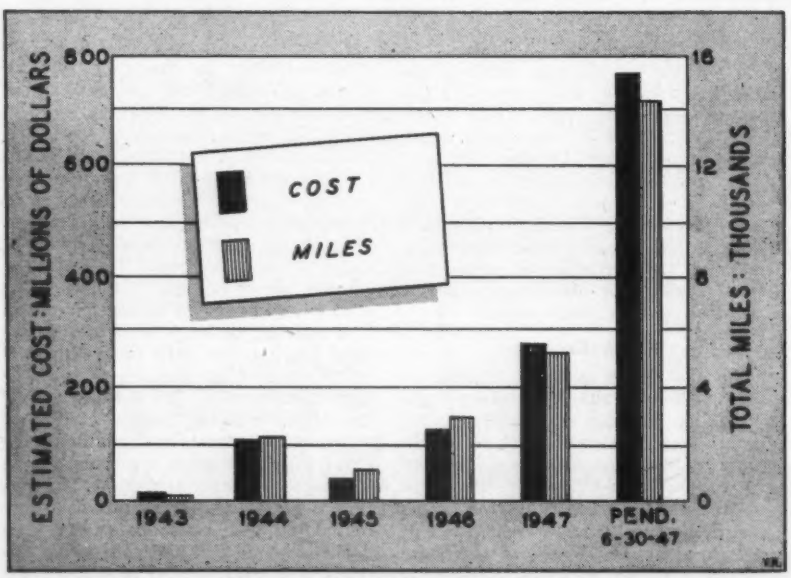
TABLE 2—GAS LINE MILEAGE

Year	Total miles
1938	182,320
1939	186,850
1940	190,270
1941	195,130
1942	198,790
1943	202,780
1944	210,270
1945	218,440
1946	228,350

However, these figures include both "transit" and "distribution" lines. A.G.A. estimated that the transit-line mileage was 81,000 in 1938, 83,100 in 1939, and 84,700 in 1940. Assuming that the proportion remains about the same the estimate of 100,000 miles of transit lines at present would not be far wrong. One difficulty is that there is no universally accepted demarcation between field or gathering lines, transit or trunk transmission lines, and distribution lines.

The American Gas Association estimates gas pipe lines of all types at the end of 1946 amounted to more than 320,000 miles. This figure, however, includes city mains as well as long-distance transmission lines. Besides the 228,350 miles of natural-gas lines, there are, according to A.G.A., 71,290 miles of manufactured-gas lines, 18,460 miles of mixed natural and manufactured-gas lines, and 2,810 miles of lines carrying L.P.G.

Probably the most thorough study ever made of the natural-gas industry was by the Federal Trade Commission in the early thirties as a part of its investigation of public-utility holding companies which led to enactment of the Natural Gas Act and other legislation. FTC reported that in 1932 natural-gas pipe lines were operated to some extent



This chart graphically illustrates the postwar upsurge in construction of natural-gas pipe lines. The vertical bars represent total costs and miles of pipe included in all projects authorized by Federal Power Commission in each fiscal year. The right bar shows the mileage and cost involved in all construction proposals pending before the commission June 30, 1947

TABLE 3—INTERSTATE MOVEMENTS OF NATURAL GAS
(Millions of cubic feet)

Year	Total marketed production* (1)	Transported by pipe lines: Volume (2)	Per cent of (1) (3)	Interstate transportation: Volume† (4)	Per cent of (1) (5)	Per cent of (2) (6)
1945	‡3,918,686	‡2,569,904	65.3	‡1,105,760	28.2	43.1
1944	3,711,039	2,500,089	67.2	1,029,758	28.0	41.1
1943	3,414,689	2,306,931	67.4	990,457	29.0	43.0
1942	3,053,475	1,988,177	65.0	916,969	30.0	46.0
1941	2,812,658	1,743,657	62.0	815,872	29.0	47.0

Source: U. S. Bureau of Mines, Minerals Yearbooks.
*Includes field uses and consumption for carbon-black manufacture, both of which generally occur near the points of production. †Includes relatively small quantities exported to Mexico and Canada, amounting in 1945, for example, to 18,207,000,000 cu. ft. ‡Preliminary figures.

in 35 of the 48 states, and that the total trunk-line mileage was approximately 52,000 miles. This included both interstate and intrastate trunk lines.

Since 1932 the volume of natural gas transported by pipe lines has increased three-fold, as shown by the U. S. Bureau of Mines figures in Table 3. The lines laid since that date are, for the most part, considerably larger in diameter than those in use in 1932, so the mileage now is probably about double what it was then.

With the FPC, the difficulty is that the agency does not know how many miles of line were placed under its jurisdiction by enactment of the Natural Gas Act. As required by the law it issued "grandfather certificates" to all interstate companies already in the business without requiring them to submit an inventory of their property.

As individual pipe-line companies have become involved in rate, valuation, or other proceedings they have submitted data showing details of their physical plants, including miles and sizes of gathering, trunk, and distribution lines, number and horsepower of compressor stations, and volumes of gas transported. But the commission has never undertaken to put these figures on a uniform basis and total them up.

All natural-gas companies subject to FPC jurisdiction submit annual statistical reports which are supposed to include complete details of property owned and of all operations. But to date the commission has concentrated on getting the companies to be complete and accurate in reporting their financial data and it has not checked up on the physical property figures in the returns.

A trial tabulation of the 1945 reports of the 87 largest companies (classes A and B—having annual gas operating revenues of more than $250,000) reporting to FPC revealed the data in Table 4.

The tabulation in Table 4 is presumed to include any wholly intrastate transmission lines of the reporting companies, but it does not include any of the facilities of the smaller interstate companies subject to FPC jurisdiction, nor lines owned by wholly intrastate companies, such as those in California. Also, FPC has made no check to determine if the companies reported on a uniform basis and with the desired completeness. In course of time the commission hopes to develop dependable statistics on the natural-gas transmission industry, but at present it is so unsure of the reliability of its data that it does not release them officially.

Much more complete statistics are published by FPC on investments, income, and operations of the 111 companies it considers to be interstate natural-gas pipe-line companies and which report to it regularly. Table 5, made up of selected items from the composite statistics of these companies, gives some indication of the size and recent growth of the natural-gas pipe-line industry.

TABLE 4—TABULATION BASED ON 1945 REPORTS OF 87 COMPANIES TO FPC

	Miles of pipe owned
Field lines	19,981
Transmission lines:	
0- 5 in. (i.d.)	11,338
5-10 in. (i.d.)	22,534
10-15 in. (i.d.)	8,537
15-20 in. (i.d.)	11,561
20-25 in. (i.d.)	6,154
Over 25 in.	1,006
Total transmission lines	61,132

Compressor stations:	No.	Horsepower
Field	48	44,326
Transmission	470	1,320,049

TABLE 5—STATISTICS OF NATURAL GAS COMPANIES REPORTING TO FEDERAL POWER COMMISSION

(Data of 85 reporting companies, Classes A and B)

Item—	1946	1945
Number of Customers		
Residential	3,077,390	2,950,960
Commercial	277,741	262,704
Industrial	14,435	13,607
Others	9,532	9,905
Total ultimate consumers	3,380,406	3,237,176
Other gas utilities	1,308	1,265
Total customers	3,380,406	3,238,441
Gas Sales (in 1,000 cu. ft.)		
Residential	220,520,000	207,795,000
Commercial	59,034,000	57,040,000
Industrial	759,095,000	742,140,000
Other ultimate consumers	44,622,000	82,522,000
Total sales to ultimate consumers	1,083,271,000	1,089,497,000
Sales to other gas utilities	1,559,022,000	1,465,151,000
Total sales	2,642,293,000	2,554,648,000
Revenues		
Gas plant assets	$1,975,171,222	$1,900,368,600
Operating revenue	575,392,481	549,214,706
Operating expenses	343,395,771	312,675,607
Depreciation and amortization	54,682,993	55,673,142
Taxes	68,093,766	75,460,130
Total deductions	466,172,530	443,808,879
Net operating revenue	109,219,951	105,405,827
Income from gas plant leased to others	118,457	113,045
Gas operating income	109,338,408	105,518,872

Continuous-Strip Right-Of-Way Photography

Aerial photographing of pipe-line right-of-way on a continuous strip of film through an open lens without any shutter action is being accomplished by Gleason Romans, manager, Air Plane Pipe Line Patrol Co. His objective is to provide practicable, acurate photographic records of rights-of-way which may be made periodically, possibly once a year. To compare existing conditions with those of a year ago, two films exposed a year apart may be projected simultaneously on two screens. Furthermore, Romans plans to go a step further and apply his method to aerial photography done in preparation for surveying for new lines.

Special equipment has been developed by Romans for photographing from an airplane flying at an altitude of 200 to 250 ft. above the ground at 75 to 90 m.p.h. and for projecting the developed film on a screen so that it appears to pass before the eye at the rate of 35 m.p.h.

The photograph is taken through a narrow open slot in a large camera suspended on gimbels where it is maintained in a level position by a gyroscope.

In preparation for photographing, much care has been taken in order to correctly synchronize the speed of the film with the ground speed.

This open-lens procedure has been developed with the collaboration of major pipe-line-company engineers.

During the war an aerial-photography continuously open-lens method was applied at higher elevations by the U. S. Army in reconnaissance over hostile territory. But the Army method did not attempt to record the details of ground features as accurately as pipe-line organizations would require for a right-of-way study.

The continuous-strip photographic method used by Romans provides a sharper and more accurate picture than obtained by a movie camera. Furthermore, continuous strip photography uses less than 5 per cent of the amount of film required by moving-picture methods.

RECORD EXPANSION

Under Way in Natural-Gas Transmission

by John E. Boice

SOME very comprehensive statistics and trends on petroleum pipe-line operations, on carriers reporting to the Interstate Commerce Commission, are obtainable from data tabulated by its Bureau of Transport Economics and Statistics.

All oil pipe-line companies do not file annual reports with the ICC as some are private or intrastate lines. Those reporting, however, number 74, and represent all the major companies having approximately 80 per cent of the total mileage in the United States. The Government-owned Big Inch and Little Inch lines constructed during the war emergency did not report to the commission during the years operated. Pipe-line companies located in California do not report to the commission as their oil movements do not cross the state line.

ABLE 1—MILES OF LINE OPERATED

Year—	No. of companies reporting to I.C.C.	Crude oil			Refined oil	Grand
		Gathering	Trunk	Total	trunk	total
1938	59	38,874	51,781	90,655	5,283	95,938
1939	63	39,573	53,641	93,214	5,467	98,681
1940	66	40,300	54,084	94,384	5,772	100,156
1941	71	41,858	57,502	99,360	6,075	105,435
1942	69	42,318	56,762	99,080	7,405	106,485
1943	74	42,471	57,586	100,057	8,726	108,783
1944	75	43,276	59,259	102,535	9,080	111,665
1945	74	43,994	59,576	103,570	9,781	113,351

TABLE 2—INVESTMENT IN TRUNK PIPE LINES

Year—	Investment in carrier property	Accrued depreciation-carrier property and amortization reserve	Investment in carrier property less depreciation and amortization
1938	$807,780,468	$432,832,900	$374,947,568
1939	829,646,464	445,333,349	384,313,115
1940	841,976,902	457,540,363	384,436,539
1941	885,316,742	468,447,755	416,868,987
1942	918,847,714	484,558,183	434,289,531
1943	965,464,043	514,864,787	450,599,256
1944	1,000,741,256	549,229,607	451,511,649
1945	1,042,522,828	592,339,272	450,183,556

Mileage

The increase in pipe-line mileage was rapid between 1938 and 1945 (final statistics for the year 1946 are available in annual reports for the individual companies, but the combined figures have not yet been tabulated) and reflects expansion during the war when submarines were playing havoc with normal tanker movements from the Gulf Coast to the Atlantic seaboard. From the following tabulation it will be noted that the mileage of gathering lines increased 5,120 miles during these years, crude-oil trunk lines increased 7,795 miles, and refined oil lines 4,498 miles, or a total increase of 17,413 miles. Some of this increase is due to additional small companies filing reports with the commission but their mileage is rather insignificant.

Investment in Carrier Property

Investment in pipe-line property has followed the general increase in mileage. From the totals shown in Table 2 it will be observed that at the end of 1945 investment in trunk lines represented more than 88 per cent of the total. The grand total investment at the end of 1945 of $1,042,522,828 is broken down into four major components of property as follows:

		Per cent
Pipe line, including fittings and labor laying	$713,453,304	68.44
Pumping equipment	82,443,133	7.91
Oil tanks	70,974,933	6.81
Buildings	51,258,839	4.92
Total	$918,130,209	88.07

The carriers had depreciated approximately 57 per cent of the total investment as of December 1945.

Oil Transported

Table 3 shows the pipe-line movement of crude oil and refined oils during the years 1940 to 1945, inclusive.

The figures in Table 3 indicate that trunk-line movements of crude oil in 1945 were nearly 55 per cent greater than in 1940 while similar movements of refined oils increased 140 per cent between these years.

Considerable duplication results in tabulating oil movements because each reporting carrier indicates the transportation of oil through its own pipe lines. It can be appreciated that a barrel of oil originating in Texas, for instance, may pass through a number of connecting lines before its ulti-

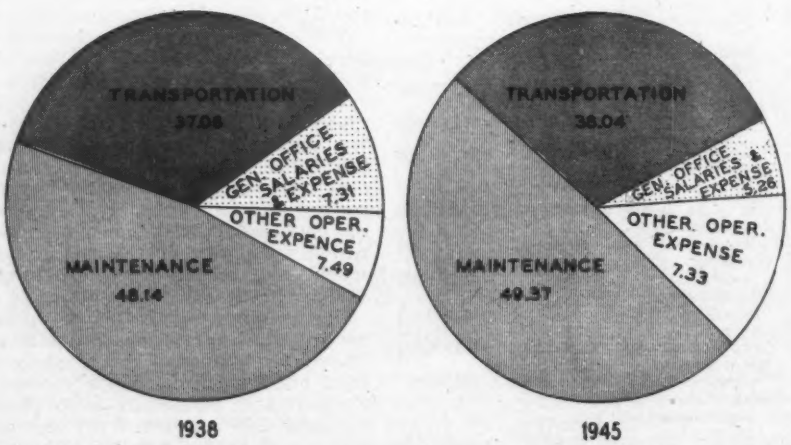


Fig. 1—Chart showing how operating expenses have changed since 1938

THE AUTHOR

JOHN E. BOICE is a truly career government employe. Of his more than 35 years of continuous service, some 31 years have been with the Interstate Commerce Commission at Washington and San Francisco, largely in the engineering section, Bureau of Valuation. As valuation analyst his duties have consisted principally in assisting the commission with the preparation of basic engineering and tentative valuation reports on railroad and pipe-line companies.

Due to his general knowledge of oil pipe lines in this country he was loaned to Petroleum Administration for War from 1942 to 1945 where he served as senior transportation engineer. Before completing that assignment he assisted in preparing the testimony and exhibits for presentation to the senatorial committee investigating petroleum resources, and also in writing the history of wartime transportation.

While on the West Coast, Boice completed a course in transportation and traffic management at University of California.

mate delivery to the East Coast and be counted a number of times. The number of barrel-miles the oil moves via trunk lines is considered more accurate in determining the through movement.

The ICC compiles quarterly statements (Q-600) showing revenues and traffic of large oil pipe-line companies (both crude and refined) having annual operating revenues of more than $500,000. A total of 44 companies report within that class. The figures in Table 4 are taken from such statements.

TABLE 3—PIPE-LINE MOVEMENT OF CRUDE AND REFINED OILS
(Thousands of barrels)

Number of barrels received into system:	1940	1941	1942	1943	1944	1945
From connecting carriers:						
Crude oil	439,807	560,750	683,610	761,200	880,451	859,318
Refined oils	23,266	24,467	22,448	53,012	93,471	78,035
Total	463,073	585,217	706,058	814,212	973,922	937,353
Originated:						
Crude oil	886,352	971,112	981,478	1,122,597	1,277,197	1,291,922
Refined oils	71,950	82,373	92,321	143,517	146,967	149,967
Total	958,302	1,053,485	1,073,899	1,266,114	1,424,164	1,441,889
Total received into system	1,421,375	1,638,702	1,779,857	2,080,326	2,398,086	2,379,242
Number of barrels delivered out of system:						
To connecting carriers:						
Crude oil	427,490	538,555	670,540	808,104	959,614	894,147
Refined oils	23,395	24,539	21,594	57,685	83,049	70,322
Total	450,885	563,094	692,134	865,789	1,042,663	964,469
Terminated:						
Crude oil	884,396	997,994	980,316	1,074,920	1,190,321	1,243,601
Refined oils	71,915	81,266	91,360	136,048	156,368	157,335
Total	956,311	1,079,260	1,071,676	1,210,968	1,346,689	1,400,936
Total delivered out of system	1,407,196	1,642,354	1,763,810	2,076,757	2,389,352	2,365,405
Number of barrels have trunk-line movement:						
Crude oil	1,112,326	1,283,735	1,347,743	1,504,076	1,749,577	1,721,440
Refined oil	95,236	106,416	112,455	195,906	251,399	228,226
Number of barrel-miles (trunk lines):						
Crude oil (thousands)	282,192	324,036	346,051	393,029	437,679	429,942
Refined oil (thousands)	23,740	26,748	38,422	60,896	70,916	65,369

TABLE 4—REVENUES AND TRAFFIC OF LARGE OIL PIPE-LINE COMPANIES

	Transportation revenue (Accounts 501 and 551)		No. of bbl. of oil originated on line and received from connections	
	1946	1945	1946	1945
Four quarters	$273,478,613	$279,982,686	2,105,197,315	2,174,677,083
	(Decrease 2.3 per cent)		(Decrease 3.3 per cent)	
	1947	1946	1947	1946
First quarter	$68,717,486	$64,557,635	522,717,160	490,806,089
	(Increase 6.4 per cent)		(Increase 6.5 per cent)	
Second quarter	$73,004,561	$68,568,490	568,303,561	528,815,230
	(Increase 6.5 per cent)		(Increase 7.5 per cent)	

TABLE 5—GATHERING LINE AND TRUNK-LINE REVENUES

Year—	Gathering line	Trunk line	Total
1938	$45,531,735	$181,277,275	*$228,215,055
1939	44,377,757	168,088,381	212,466,138
1940	47,330,691	178,429,791	225,760,482
1941	54,003,712	197,681,060	251,684,772
1942	53,513,888	191,346,268	*245,061,060
1943	56,507,655	220,144,596	276,652,251
1944	62,584,569	247,609,884	310,194,453
1945	63,415,033	240,853,099	304,268,132

*Difference due to adjustment not allocated.

TABLE 6—BREAKDOWN OF EXPENSES BETWEEN GATHERING AND TRUNK LINES

Year—	Gathering line	Trunk line	Total	Ratio between revenue and operating expenses
1938	$26,428,207	$72,332,916	$98,761,123	43.28
1939	25,529,039	71,600,827	97,129,866	45.72
1940	26,626,436	75,292,534	101,918,970	45.14
1941	28,533,819	81,914,622	110,448,441	43.88
1942	31,117,020	92,389,948	123,506,969	50.40
1943	34,387,929	114,060,008	148,447,937	53.66
1944	39,456,363	132,911,147	172,367,510	55.57
1945	41,852,995	149,814,760	191,667,755	62.99

The decline in both transportation revenue and traffic in 1946 from 1945 took place between January and September. Quarterly reports for the first 9 months of 1946 indicate revenue and traffic were 5.7 per cent and 6.9 per cent, respectively, below the same months of 1945. The last quarter of 1946 and the first half of 1947, however, reflect a trend in the opposite direction and substantiate the present all-time high demands for refined products. During the past 9 months reporting pipe-line companies received $211,594,825 in transportation revenue compared with only $197,092,325 for the same months in 1945 and 1946, an increase of 6.9 per cent. They also handled during this latter period 1,628,012,619 bbl. of oil compared with only 1,509,557,423 bbl., an increase of 7.3 per cent.

Operating Revenues

Operating revenues increased from $228,215,055 in 1938 to $304,268,132 in 1945.

The segregation between gathering line and trunk-line revenues are shown in Table 5.

In 1945, the gathering lines provided approximately 21 per cent and trunk lines 79 per cent of the total operating revenue. In the same year transportation charges accounted for

96.86 per cent, storage and demurrage 0.01 per cent, rents 0.37 per cent, and miscellaneous 2.76 per cent of the total operating revenue.

Operating Expenses

Operating expenses almost doubled between 1938 and 1945 whereas operating revenue increased only about 33 per cent. This disparity can be attributed directly to increased cost of labor and materials. Table 6 shows a breakdown of expenses between gathering and trunk lines for the years 1938 to 1945, inclusive.

Table 7 is a further breakdown which compared various items of cost in 1938 with 1945.

The change between 1938 and 1945 is illustrated by Fig. 1.

Pipe-Line Taxes

Like in all business, taxes have increased tremendously during recent years and have been a large factor in reducing net pipe-line operating income. As shown by Table 8, government taxes increased 147 per cent between 1938 and 1944, whereas state taxes remained rather stationary.

The decline in government taxes during 1945 reflects in general adjustments made on facilities constructed during the war for which carriers were allowed to amortize investment.

Net Pipe-Line Operating Income

Notwithstanding that operating revenues were generally upward between 1938 and 1945, increased operating expenses and taxes have resulted in a downward trend in net pipe-line operating income, as indicated in Table 9.

The diminution of operating income is illustrated by Fig. 2.

Analysis made of actual operations of one particular pipe-line company during the years 1941 to 1946 shows conclusively the general upward trend of expenses and the decrease in income, when taken on a unit basis. Table 10 shows in cents the revenue received for transporting 1 bbl. of crude oil and the net income remaining after deducting operating expenses and taxes.

TABLE 7—COST COMPARISON BETWEEN 1938 AND 1945

	1938	1945	Per cent increase
Maintenance:			
Depreciation	$29,873,178	$51,623,918	72.81
All other	17,670,151	43,002,344	143.36
Transportation	36,596,981	72,904,726	99.21
General office salaries and expenses	7,224,233	10,086,215	39.62
Other operating expenses	7,396,580	14,050,552	89.96
Total	$98,761,123	$191,667,755	94.07

TABLE 8—INCREASES IN TAXES, 1938-1945

Year—	U. S. Government	Other than U. S. Government	Total
1938	$24,583,342	$9,744,064	$34,327,406
1939	22,091,927	9,843,714	31,935,641
1940	31,690,185	9,593,194	41,283,379
1941	50,042,248	9,590,488	59,632,736
1942	53,475,632	9,746,241	63,221,873
1943	56,402,365	9,181,772	65,584,137
1944	60,794,752	9,192,475	69,987,227
1945	35,729,646	9,743,325	45,472,971

TABLE 9—TREND IN NET PIPE-LINE OPERATING INCOME

1938	1939	1940	1941	1942	1943	1944	1945
$95,126,526	$83,400,631	$82,558,133	$81,603,595	$58,332,218	$62,620,177	$67,839,716	$67,127,406

TABLE 10—REVENUE RECEIVED FOR TRANSPORTING BARREL OF CRUDE OIL
(All figures in cents per barrel)

	1941	1942	1943	1944	1945	1946
Operating revenue	14.87	14.74	14.25	11.57	11.50	12.24
Operating expenses	5.20	4.83	5.36	5.76	6.33	6.40
Net revenue	9.67	9.91	8.89	5.81	5.17	5.84
Taxes	1.56	4.47	4.07	2.82	3.21	2.86
Operating income	8.11	5.44	4.82	2.99	1.96	2.98
Per cent of revenue	54.57	36.92	33.82	25.84	17.05	24.39

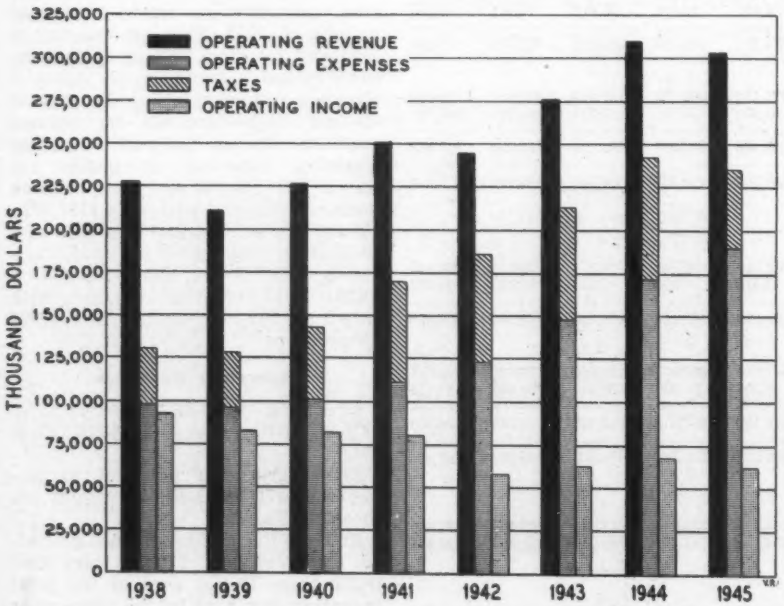


Fig. 2—Comparison of operating revenue and operating income

American Development of Synthetic Gasoline Urged

Development of synthetic-gasoline production within the United States was advocated as a national policy in an address by Henry S. Fraser, former chief counsel of the Senate special committee investigating petroleum resources.

He pointed out that less than one-third of the proved oil reserves of the world are located in the United States and that the Middle East is now the world's largest oil reservoir.

Fraser contended that synthetic gasoline "can be produced from natural gas at costs similar to present costs of producing gasoline from crude oil." He maintained that the answer to the United States' "dilemma" is the development of synthetic-gasoline production.

He said that the United States should not rely too heavily on imports from Venezuela, Arabia, and other areas, but emphasized he did not advocate abandoning American holdings abroad.

Musgrove Buys Producing Properties in Kansas

Musgrove Petroleum Corp., Wichita, has purchased two producing leases in the Trapp pool of northern Barton County, Kansas, for $190,000 from Ralph J. Weaver, Ralph J. Weaver, Jr., Fred R. Holmes, R. L. Williams, and S. H. Wilson. The two leases include two Arbuckle wells and four Kansas City wells.

The first scraper, designed especially to remove heavy caked dirt. Later, teeth were welded to the cutting edges of scraping plates

Plant-Built Scrapers Effective In Cleaning Dirty Pipe Lines

by
W. F. Crutchley
and
W. S. Wright

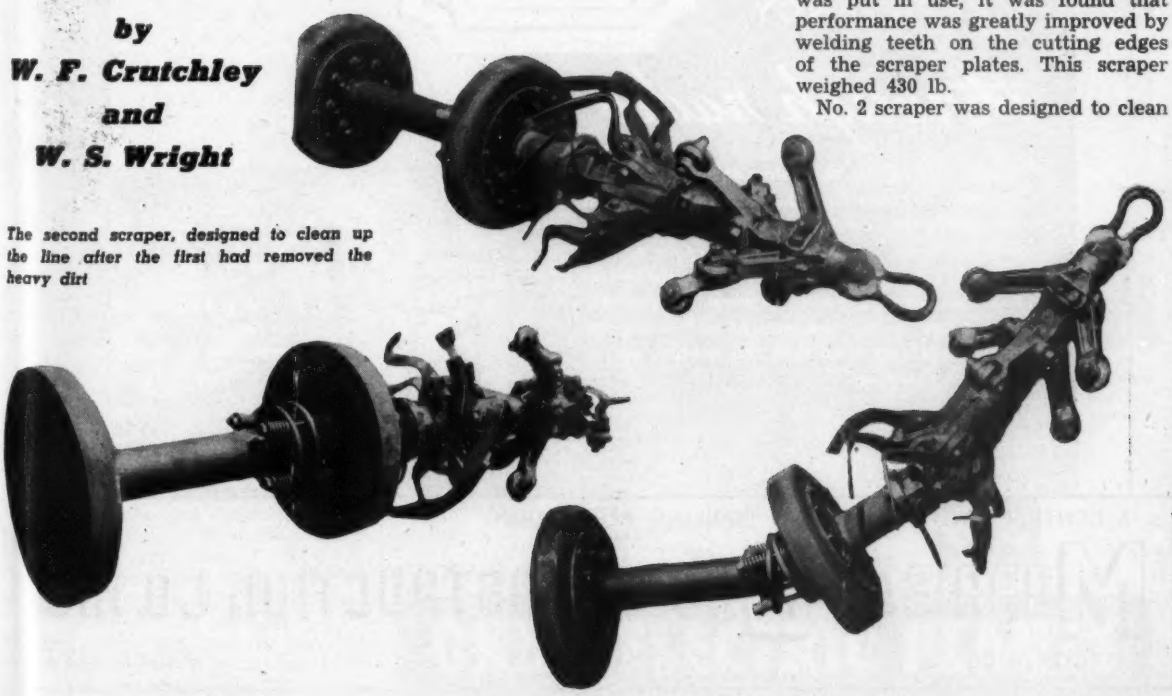
OVER a 6-year period, efficiency of Hope Natural Gas Co.'s 20-in. pipe line between Jackson and Cornwell compressing stations declined steadily. Tests showed efficiencies as low as 60 per cent in the first 10 miles north of Jackson Station. Beyond that point efficiencies were fairly normal. It was decided to scrape the 10-mile section to remove the heavy accumulation of dirt and fluid that seemed to be in the line.

This is a Dresser-coupled line, and runs through extremely rugged territory, averaging about 70 fire bends per mile, many being very acute bends. It was suspected that in some of the bends the pipe was badly buckled.

Two scrapers were designed and built in Hope's machine shop, under the direction of W. S. Wright. When assembled each scraper was 6½ ft. long, and had two drivers spaced 30 in. apart, so that it would be unlikely that both drivers would be in a buckled bend at the same time. There was a self-aligning universal joint between the drivers, and another one ahead of them. Driver backup plates were small enough to pass through 20-in. pipe buckled to 16 in. Eight bypass holes were drilled through each driver, with ½ and ¾-in. collars welded over them so that the amount of gas bypassed could be controlled by plugging off unneeded holes.

The scraping assembly on No. 1 scraper was designed to remove heavy caked dirt, and consisted of two rows of four Stellite-faced segment-shaped scraping plates mounted on hinged arms, with coil springs pushing the scrapers outward to contact with the pipe wall. Later, when this scraper was put in use, it was found that performance was greatly improved by welding teeth on the cutting edges of the scraper plates. This scraper weighed 430 lb.

No. 2 scraper was designed to clean



The second scraper, designed to clean up the line after the first had removed the heavy dirt

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through radio

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William F. Crutchley, head gas dispatcher of Hope Natural Gas Co., was born and educated in England. He came to the United States in 1919 and

W. F. CRUTCHLEY *W. S. WRIGHT*

entered service with Hope in 1924. He held various positions with the company until 1942, when he was promoted to his present position.

W. S. Wright, superintendent of main lines, Hope Natural Gas Co., joined the company in 1918. Among the positions he has held are those of gasoline-plant foreman and district superintendent. He was transferred to the main-line department in 1939, and received appointment to his present position in 1941. He was born in West Virginia in 1899.

up the line after the No. 1 scraper had removed the heavy dirt. It had 10 overlapping spring-steel scraping blades, ahead of which were 8 guide wheels held in contact with the pipe by coil springs. This scraper weighed 350 lb.

When all preparations had been made, the 10-mile section of line to be scraped was taken out of service. The next section of the line, 6 miles long, was shut in with 200 psi. pressure on it. Gas to run the scrapers was taken out of this reservoir, and the volume used was computed from the drop in reservoir pressure.

New wrinkle bends to replace the worst fire bends in the line had been made up in advance, and the crew engaged in replacing the bends worked ahead of the scraper crew.

It was not deemed practical to attempt to run the scrapers through the entire 10 miles at one time, so the line was divided into seven sections ranging in length from 0.48 to 3.03 miles, the lengths depending on local conditions. Each scraper was run through the line a number of times, depending on the amount of dirt and fluid removed. In some cases, after No. 1 scraper had been run, two or three sections of the line were connected and No. 2 scraper was run the entire distance.

Five pounds gas pressure was usually sufficient to drive the scraper at a speed of approximately 5 m.p.h. On a few occasions pressure had to be increased to overcome an obstruction. To catch the scraper as it emerged from the line, a joint of slotted pipe, followed by a plain joint

(Continued on page 255)

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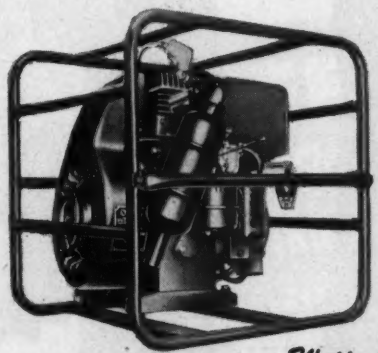

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Safety-Weld Coupling

(Continued from page 194)

In Fig. 6 chains have been placed around A and B. They are held together with a 5-ton hoist.

In this picture, the line has been filled with gasoline and the coupling has been tested to 300 psi. Gasoline is being pumped through the line.

The coupling can now be electrically welded to the pipe line.

In Fig. 7 the welder has completed the first pass or stringer bead around each end of the coupling. The clamping chains and 5-ton hoist were then removed.

On this particular job, welding followed the sealing of the coupling with very little delay. However, if safety considerations had dictated delay of the welding the pumping could have been continued for several days (or weeks) before completion of the work.

Figs. 8 and 9 show the completed welded joint. There is no danger of leaks developing through worn or disintegrated packing. The coupling is as strong or stronger than the rest of the pipe line which it joins.

The thickness of the coupling wall at the ends where the welds are made is designed to be 1¼ times the pipe-wall thickness, in accordance with A.S.A. code for pressure piping for socket and fillet weld dimensions.

Several changes in the design of the coupling have been made during the past 10 months. It has been made longer to allow for more space between packing rings. Clamping set screws have been provided, eliminating the use of anchors as shown in Fig. 6. Fig. 10 shows the safety-weld coupling as it is being manufactured at present. The coupling in this view is for 4-in. pipe. The four ⅝-in. cup-point set screws at each end of the coupling eliminate the need of installing chains or clamps for holding the pipe together, as shown on the older coupling in Fig. 6. The set screws are also used for centering the pipe inside the coupling, making the annular space between the pipe and the coupling equidistant all of the way around.

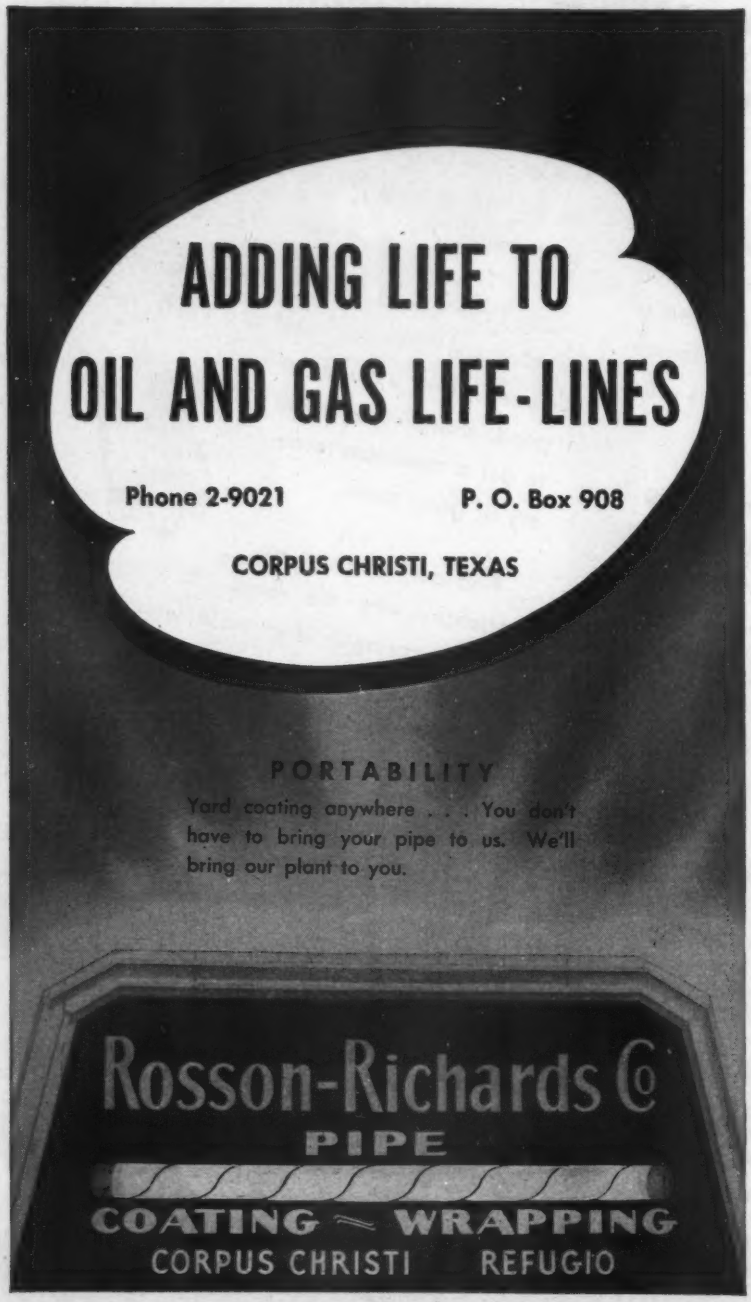
Clamping is not always necessary, but when cold liquid is pumped into a hot, empty line, it may, under certain conditions, cause the steep pipe to contract sufficiently to pull out of the coupling if it is not clamped.

A 4-in. coupling was tested with the four ⅝-in. set screws tightened onto a 4-in. pipe by Herron Testing Laboratories at Cleveland .They reported that a force of 23,000 pounds was exerted before any movement between pipe and coupling was noticed. They estimated that 30,000 lb. would be required to entirely pull the pipe out of the coupling.

As shown in Fig. 6 the 5-ton hoist is holding a 6-in. line with 1,000 ft. of it stripped and lying bare. A 6-in. coupling with six clamping screws will hold from 30,000 to 45,000 lb. without pulling out. Thus, a large margin of safety is provided by the set screws. After the stringer beads are run, the set screws are removed and the coupling is plug welded to the pipe through the set screw holes.

By using a safety-weld coupling the line can be put back in service without the use of a cutting torch or welding equipment. The replacement section if more than one joint long could be welded in an outside safe area and then moved into place. The old section would be cut out with wheel pipe cutters, a hack saw, or other mechanical cutting device. The couplings would be installed, set screws tightened, packing rings pressured, and then tested. After testing, the line would be replaced into service. Several days or weeks later the couplings would be welded to the pipe after all hazardous vapors had cleared away.

Standard Oil Co. of Ohio and its pipe-line subsidiaries have adopted the safety-weld coupling method as standard procedure on all section replacements. The use and application of the coupling is taught in the companies' safety-training schools as part of the safety programs.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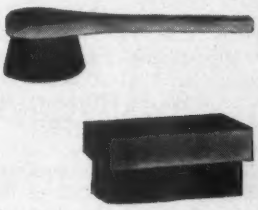
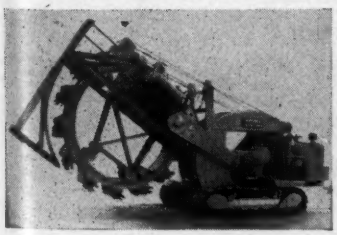


Parsons Wheel Trenchliner



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Tipton Clamp

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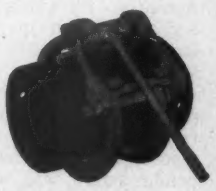

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Pipe-Line Construction Making Rapid Advances Toward Assembly-Line Efficiency

Left: Factory bends installed on 26-in. loop laid in Nebraska by J. R. Horrigan and O. E. Dempsey for Natural Gas Pipeline Co. of America. Below: Pipe-bending machine built at Williams Brothers' Houston shop for foreign service. This uses a 24-in. shoe and bends 40-ft. joints of 24-in. pipe with ½-in. wall thickness

THE variety of improvements in pipe-laying methods which have applied in 1947 indicate acceleration of progress in efficiency, particularly for the construction of large-diameter lines.

While the basic equipment of a main-line spread such as large ditchers, side-boom tractors, dope machines, etc., continues to be operated as in recent years, there have been numerous developments in construction details for increasing speed, accuracy, and quality of pipe line construction work.

Important money savings are reported in 1947 by the use of two-way radio communication between supervisors, utility welders, trucks, field headquarters, etc. Airplanes are facilitating contacts of executives with work in the field which expedites progress.

Measures employed are discussed here in the order of the various steps from the front to the rear in pipe-laying operations.

A well-cleared right-of-way is essential for satisfactory progress of spread operations. More power saws have been used in brush gangs as 1947 projects progressed. More rooters are observed in right-of-way gangs, particularly in wooded country.

Faster large ditching machines are being built. Older types of ditchers have been rebuilt and "suped up" for greater speed and efficiency. Transmission installations afford more flexibility in controlling rate of digging of the bucket wheel. In addition to the usual method of trenching to the full depth of the ditch, some two-stage ditching is done either by a preceding ditcher digging to half the depth or digging a pilot ditch of lesser width from the one dug by the larger ditcher that follows.

Most of the bending of large-diameter pipe is now done by the C.R.C. power-operated bending machine which was initiated during the building of War Emergency Big Inch lines. This machine has demonstrated the advantages of bending large-diameter pipe by the cold bending method developed by Jim Cummings.

During the building of loops for Mississippi River Fuel Corp. an innovation was introduced in the shoe equipment for a power-operated bending machine. This shoe was designed by C. L. (Red) Kelso, bending foreman for R. B. Potashnick. Manufacture of bending machines of this type has been undertaken by Perrault Brothers. The Kelso shoe is of a caliper type which makes it possible to exert a constant pressure over two-thirds of the surface of the pipe during bending for efficient operation, tending to avoid buckling. Automatic opening and closing facilities handling of pipe when joints are "out of round." A bend of 2° is made at each wrinkle.

Special bending equipment for

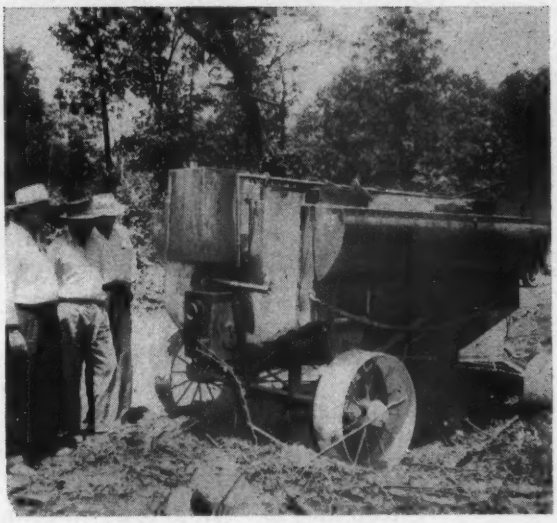
large-diameter pipe has been developed by Williams Brothers interests for foreign operations. This is built on a large tractor with rugged A-frame and shoe, thus giving mobility for rapid manipulation on the right-of-way. During bending the ends of the pipe are pulled upwards by winch cables.

Factory bends are being used in the bending of several large-diameter natural-gas lines this year. In most cases the factory bends are installed for bends at the more acute angles, the more obtuse bends being made by bending machines. The desired angle of bend is either achieved by a single factory bend or by combining several factory bends of various increments to procure the angle of bend desired.

Left, above: Internal line-up clamp on 26-in. natural gas line transmitting to Chicago

Right, above: By protecting against the effect of high winds with this special equipment it is possible to continue to maintain the quality of welding

Right: Tar kettle developed this year with power-driven bar-type agitator that scrapes the bottom



Factory Bends for Looping

In the looping of its Chicago trunk line this year, Natural Gas Pipe Line Co. of America has been using factory bends for all bending in pursuance of a practice started 7 years ago. When the author visited laying of pipe for one of the company's loops in southeastern Nebraska, Oscar E. Dempsey, one of the contractors for the project, explained the methods employed and their advantages developed by him in the effective application of factory bends.

Stakes are driven at 100-ft. intervals along the right-of-way. The engineer surveying in advance of operations measures the pipe and the ground. He determines the number of joints and joint measurements between each bend. Stake markings tell the ditching machine operator how deep the ditch is to be dug. For the ditch is "tailor-made" to fit the bends.

Factory bends are ordered and delivered to locations along the line according to the engineer's specifications. A copy of the engineer's specifications comes to the pipe gang foreman 2 or 3 days ahead of the time when the pipe gang reaches the particular section to which the specifications apply. Bends are supplied by the manufacturer, A. O. Smith Corp., in cuts from 1° to 5°. To exemplify how they are assembled: an 11° bend may be made by welding two 5° bends and a 1° bend; a 6° bend is made by welding two 3° bends.

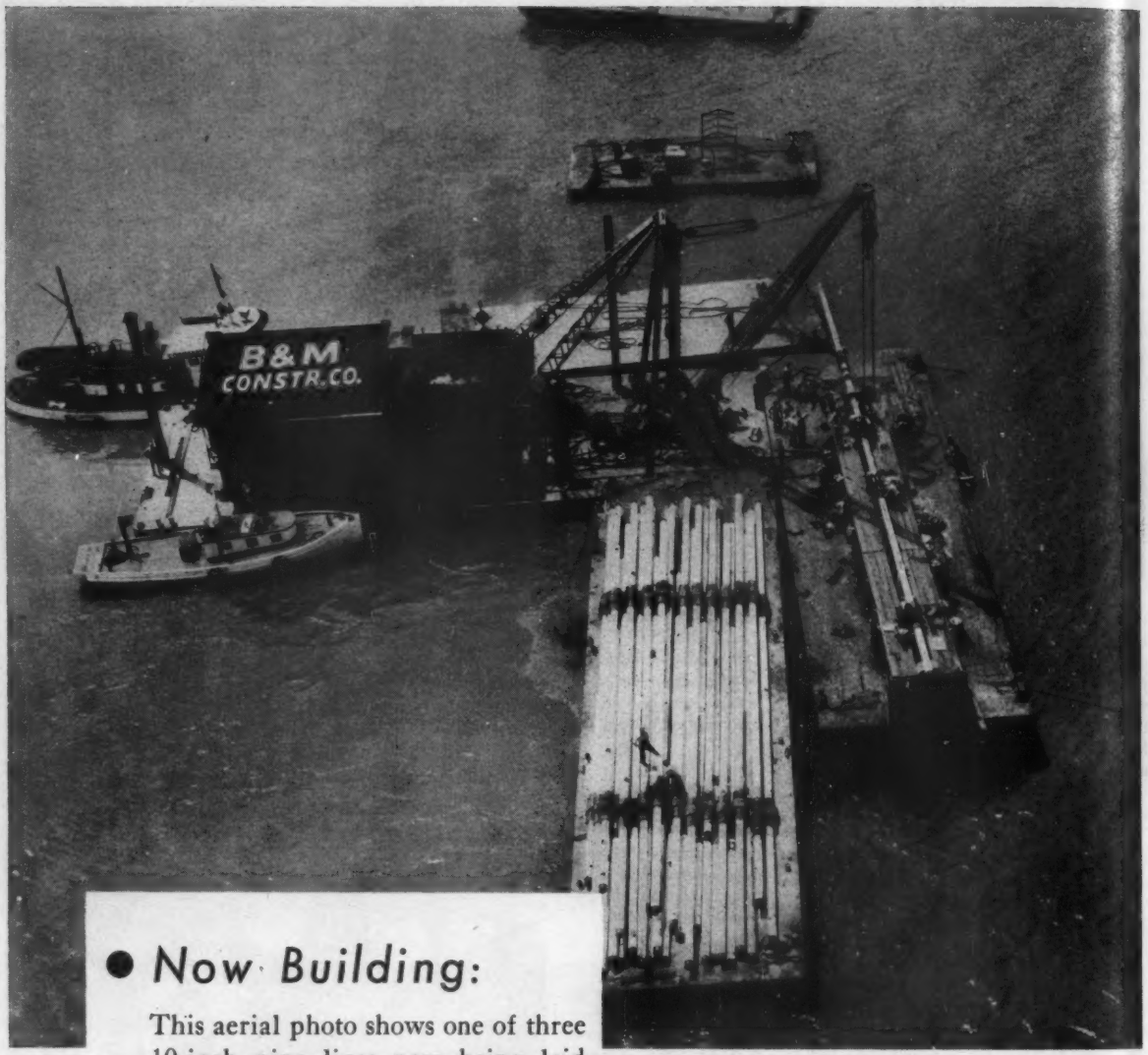
Internal line-up clamps, mostly of hand-operated mechanical types, are widely used this year in all big-inch pipe because of the rapidity and accuracy with which they attain proper alignment. Power-driven machines for buffing the beveled ends of pipe are to be found on the big jobs.

To avoid the stopping of welding during windy weather, special wind breakers made of rubber have been developed by Oscar E. Dempsey. These are valuable in enabling contractors to avoid costly shut down.

Gamma ray or radiographic inspection of welding has demonstrated its usefulness on crude-oil and natural-gas lines in California in 1946 and 1947, and it will be applied in 1948 on large scale foreign pipe laying.

In the laying of most of the big-inch projects, the pace set for the entire spread to a large extent depends on the speed of the pipe gang. There are usually 14 welders for each spread: 2 tack welders, 2 utility welders, and 10 bell-hole welders.

There is a trend among both petroleum and natural-gas pipe lines to utilize coal-tar enamels to an in-



● Now Building:

This aerial photo shows one of three 10-inch pipe lines now being laid across the Mississippi River (80 ft. deep and 3400 ft. across) in connection with 22 miles of 16 and 12-inch lines to the Barataria Gas Fields, adjacent to New Orleans, for the United Gas Pipe Line Co.

● Recently Built:

1100-foot, 72-inch tunnnel . . . 20 feet under railroad yards. Also 5 miles of 36-inch line at Omaha, Nebraska.

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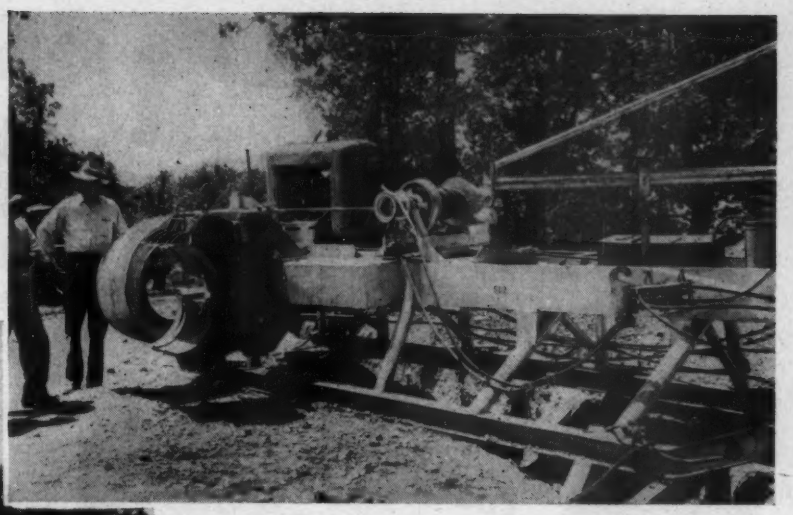
creasing extent as coatings for the usual type of pipe protection. Most trunk lines are being coated with coal-tar or asphalt coating and wrapped with glass mat or asbestos felt or both for their entire length.

Dope is heated for the majority of large 1947 projects in the new type C.R.C. kettle, with power operated spiral agitator and thermostatic control. The kettle, mounted on a truck or trailer, is usually loaded from special equipment at the railhead.



Above: Power-operated bending machine with caliper-type shoe

Left: Large tar kettle with power-driven spiral agitator and thermostat control introduced to pipe lining early in 1947

This summer a kettle of a size similar to conventional kettles for doping operations, has been introduced to pipe-line operations on Mississippi River Fuel Corp.'s looping operations. This new type of kettle, developed by Perrault Brothers, has agitator equipment fabricated from 1½-in. square steel bars on the bottom of the kettle. When the kettle is in use these agitator bars are moved back and fourth by a 9-hp. air-cooled gasoline engine which operates through a speed reducer. Through this scraping action, the bottom of the kettle is swept clean. Either diesel fuel or kerosine is burned for fuel.

The flame is spread through the fire box by a blower fan. This type of kettle, like the common type of dope kettle, is loaded from the ground on the job and towed by tow tractor along the right-of-way. It can be heated in 2 hours.

Cleaning, priming and dope machines of types developed in previous years are being used.

Various methods are used to protect coating from running, after it is applied. These include either kraft paper wrapping, or white washing to deflect the heat of the sun. On projects where pipe is protected by water-work enamel, the underside, in some cases, is cooled by a water spray following the dope machine; immediately afterward, the pipe goes into the ditch and is backfilled completely. Some companies lower in soon after doping and then "shade" the pipe with a light covering of backfill prior to final backfilling which follows later.

Mechanical Boring Increasing

Mechanical boring for road crossings is increasing because of its advantages over the hand methods. Boring by the rotary method has been discarded by Oscar E. Dempsey who uses punching action, similar to that of cable tools, for his machines in service in 1947 which, under good conditions, can cut an average road crossing at the rate of 100 ft. per hour. Such equipment is pneumatically operated.

In the laying of pipe for Magnolia Pipe Line Co.'s Beaumont-Hearne 12-in. the contractor, Smith Contracting Corp. is utilizing units of equipment, for various construction processes, which operate along the right-of-way under their own power instead of being towed in the customary way. These units are made at the O. R. Smith shop.

Construction men are utilizing a variety of methods in laying long river crossings, bay crossings, and sea loading lines. Expensive experience has taught that it is impracticable to attempt to support long sections of pipe on pontoons. The towing of long sections of pipe has been successfully done where attention has been given to having the tow line as short as working conditions allow.

There is an increase in the use of the well-point system of dewatering ditches in connection with laying across sandy rivers in dry seasons. In the laying of pipe for a bay crossing in California, a method was employed for placing long welded sections in a ditch filled with water from which they were towed seaward. It is a convenient method provided the ditch does not cave.

With the handling of larger-diameter pipe under modern conditions, it is profitable to give close attention to certain details of pipe laying by a main line spread. Seconds saved in the handling of each joint, particularly by the pipe gang, can materially increase the day's progress.

The significance of the present big-inch period of crude-oil pipe lining is indicated by the fact that most of the main trunk-line mileage is now being laid with pipe from 16 to 22 in. in diameter, while up until 4 years ago it was only rarely that crude-oil lines were laid with pipe larger than 12 in.

In the next 3 years much 30 and 31-in. will be laid for foreign crude-oil lines. Following the construction of the 214-mile 30-in. Southern California in 1947, it may be predicted that 30-in. pipe will be used for future large-capacity natural-gas lines. Products lines are being built largely with pipe of diameters less than 12 in. Recently, there has been extensive products pipe laying with 8 and 10-in. and much replacing of 6-in. with 8-in.

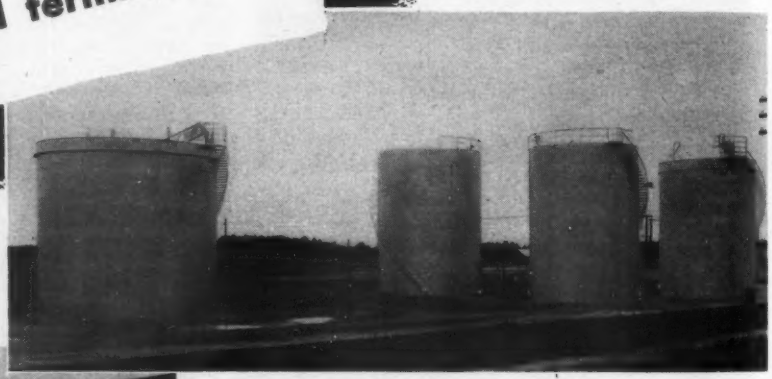
Assembly-line efficiency is increasing in pipe laying which has the distinction of being the most rapid type of cross-country construction conducted by any industry.

Gang organization with the modern stovepipe procedure, now prevailing, has been developed with the advantages of closer supervision. At the same time, progressive construction organizations give opportunity for the individual initiative of experienced supervisors.

HORTON

Storage tanks and evaporation-prevention devices to meet specific requirements of pipe line stations and terminals

THE HORTON DOUBLE-DECK FLOATING ROOF



Right: The tanks at the extreme left and right in the photo have Horton Double-Deck Floating Roofs. They are 50 ft. in diam. by 48 ft. and 30 ft. in diam. by 42 ft. respectively. The other two tanks have cone roofs.

Above: View showing the rolling ladder, adjustable roof supports, manholes and vents on the top deck of a Horton Double-Deck Floating Roof. The tank is 85 ft. in diam. by 40 ft. and holds 40,000 bbls.

● The Horton Double-Deck Floating Roof is specifically designed for working or standing storage tanks at pipe line stations handling oil products that do not boil at normal temperature. It prevents all evaporation losses due to filling. It also eliminates practically all standing storage losses and reduces the danger of fire during the storage period.

The double-deck construction of the Horton Floating Roof, the effective Horton seal which closes the space between the deck and tank shell, and many other outstanding features help to make this floating roof first choice of oil men everywhere. When installed on new or existing flat bottom tanks, the Horton Double-Deck Floating Roof pays for itself in a relatively short time by the amount of evaporation loss it prevents.

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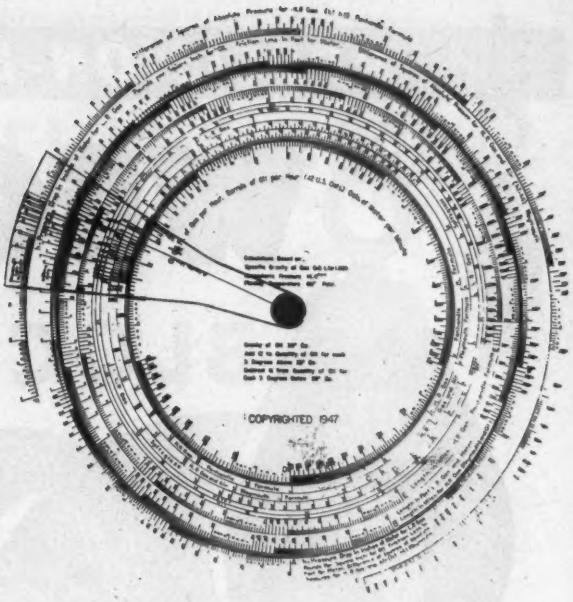
Special Slide Rule Solves Pipe-Line Engineering Problems

by Robert M. Hutchinson



This circular slide rule "packs in" many mathematical relationships, and is equivalent in accuracy to the longer linear-type rules

IF you have ever sat day after day and used an ordinary slide rule for solving problems according to a certain formula you will have learned to appreciate the old saying, "Necessity is the mother of invention."

In the past the writer was called upon to design many gas-distribution systems as well as the transmission lines which go with them and as he turned from one formula to another in search of simple methods of solution he was struck with the similarity of the various formulas which are used in the solution of liquid-flow problems.

For example, the Weymouth formula for solving problems in high or intermediate-pressure gas or air transmission, the Spitzglass formula for low-pressure gas and water distribution, and the National Transit formula for oil lines are so similar that if the various terms are properly arranged on log scales most problems of liquid flow requiring their use can be solved by one setting of the scales. This fact can readily be seen by reproducing the formulas in simplified form and explaining the terms.

Weymouth formula: (Gas)

$$Q = K \sqrt{\frac{H_1^2 - H_2^2}{L}}$$

Spitzglass formula: (Water)

$$Q = K \sqrt{\frac{H}{L}}$$

Spitzglass formula: (L.P.G.)

$$Q = K \sqrt{\frac{H}{L}}$$

National Transit Co.: (Oil)

$$Q = \sqrt{\frac{K \times H}{L}}$$

Recently another formula known as the Panhandle has also been derived for use in solving gas problems at extremely high pressures and because this and all of the other formulas have been incorporated in the special slide rule to be described, it will also be listed herewith.

Panhandle formula (high-pressure gas)

$$Q = \left(\frac{H_1^2 - H_2^2}{L}\right)^{.5394}$$

Explanation of terms:

Q is volume and for gas and air is expressed as cubic feet per hour.

For water, gallons per minute, and for oil, barrels per hour, K is a constant and varies according to the size of the pipe. In gas problems the specific gravity, flowing temperature, and atmospheric pressure are assumed. In the Panhandle formula, E is the efficiency factor and is assumed to be 92 per cent.

H_1 and H_2 represent the absolute pressure at the inlet and outlet of a pipe line, for high-pressure gas and air for both the Weymouth and Panhandle formulas.

H in the low-pressure Spitzglass formula is read as inches of water, and in the water formula as head in feet.

In the oil formula the H is termed pounds per square inch. The L is the length symbol and is read in miles for the Weymouth, Panhandle, and oil formulas and feet for the Spitzglass low-pressure gas and water formula.

The square root sign appears in all of the formulas except the Panhandle, which employs the .5394 power.

Inspection of the formulas shows that three log scales will be necessary to solve the equations; one scale to the base 10, another being the square of the scale to the base 10; and the third one being the .5394 power of the base 10 scale. The scale of the constant K will likewise be to the base 10.

Note: Numerical values for K (the various pipe sizes) can usually be secured from hand books or calculated from the formula.

An interpretation of the various formulas reveals that Q equals the root of the pressure drop divided by the length times the constant K.

Note: For the Weymouth and Panhandle formulas the reading on the log scale will be the difference of the squares of the absolute pressures at the inlet and outlet ends of the line.

From the above analysis it can be seen that a proper arrangement of log scales will make it possible to solve for one unknown quantity when the other three are known or assumed; with one setting of the slide.

Simply stated, each setting of the slide should be such that the unknown quantity will always be directly opposite one of the known ones.

By way of illustration, the pressure scale can be designated as scale A, the length scale as scale B. Scale C can be laid off so that the pipe sizes are shown for each formula and the volume or Q scale can be called scale D.

THE author graduated from Pennsylvania State College and began his work in the oil and gas business in Tulsa. He moved to San Antonio in 1924, thence to Houston in 1929, and became chief engineer of Houston Natural Gas Corp. on January 1, 1930. He remained in that position until August 1945, then became the company's director of research. He is the inventor of the Hutchison calculator described in this article and also the H. & H. odorizor.

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Then if the length shown on scale B is placed opposite the pressure drop on scale A, the volume will be found on scale D, directly opposite the designated pipe size on scale C. This procedure would obtain for each formula involving the square root and the procedure for the Panhandle formula which uses the .5394 power would be exactly the same except that scale E would be used instead of B and scale F would be used instead of scale A.

The reader can easily understand the explanation if he solves the following equation on an ordinary Mannheim slide rule:

$$Q = K \sqrt{\frac{H_1^2 - H_2^2}{L}}$$

Assuming $(H_1^2 - H_2^2) = 8$, $L = 2$, and $K = 2$. Then $Q = 4$. Set 2 on scale B under 8 on scale A, find 2 on scale C and beneath read 4 on scale D.

These are small numbers, however, and a solution such as this is, therefore, very simple, but when large numbers occur and the problems deal with big volumes, a special slide rule on which has been plotted the various pipe-line constants and which is long enough to eliminate the necessity of locating decimal points, can be used to much better advantage from both an accuracy and time-saving standpoint.

Such a special rule has been developed by the writer and is illustrated here. It is known as the Hutchison calculator and has been extensively used by petroleum and gas engineers for years. It has recently been revised to include the Panhandle formula which was mentioned at the beginning of this article. As this is now the only instrument of its kind, the story of its development might be of interest to the engineering profession.

By referring to the illustration the reader can see the arrangement of the scales as described above. He will also notice that the scales are circular and continuous. This was done in order to make the scales direct reading, not requiring the location of a decimal point.

The section of the rule between the end of the arrow above the letter C and the letter B revolves about the center pin. The indicator which also revolves is used to align the readings between scales and is likewise used to make corrections for specific gravity of gas, pressure base, interval distribution, and to convert daily and hourly gas readings back and forth. It is also used to convert inches of water to ounces, feet to pounds per square inch or vice versa.

A pressure table has also been prepared for use in solving high or intermediate - pressure gas - pipe - line problems. The table shows the gage pressure and the square of the absolute pressures $(14.4 + P)^2$ for pressures ranging from 29 in. vacuum to

1,000 lb. By using this table in conjunction with the slide rule, high-pressure-gas problems are reduced to a simple addition or subtraction.

Having determined the arrangement and number of log scales that will be needed to solve the various formulas simply and easily, the next operation is the compilation of the data to be used in plotting the scales on a drawing. In order to make the scales self-reading, the maximum number that can be plotted around the circle and still give legibility should be used. Then in order to facilitate the drafting work, the drawing should be about five times the area desired in the completed rule.

For example, if an instrument 10 in. square is desired, the drawing should be made 20 to 22 in. square and then reduced by photography.

The chief advantage of making a circular slide rule is that the equivalent of a long rule can be secured in about half the size. To illustrate, a scale laid out on a circle having a 5-in. diameter will be equal to a rule slightly under 20 in. in length, and naturally larger circles will be longer in proportion.

The method used in plotting the scales is very simple although a great many mathematical calculations must be made before the work can be started. The computations cover the conversion of the logarithms of the numbers from 1 to 100 into angles so that these angles can be plotted on the circles by means of a 360° protractor equipped with a vernier and which has been firmly attached to the drawing board to avoid movement. To convert the logarithms to angles the following calculations are made. Let us assume that the circle is to be divided into five equal scales. A circle contains 360° so, therefore, each scale will occupy one-fifth of 360° or 72°. By reducing 72° to seconds we find, therefore, that the length of each scale expressed in seconds is 257,200.

Then if 257,200 is multiplied by the logarithms from 1 to 100 expressed as a decimal of the whole and the resulting numbers be converted to degrees, minutes, and seconds, these angles can be plotted and will produce the log scale on the circle. For example, the angle for the number 2 would be calculated as follows:

Log 2 = .3010.

Seconds = .3010 × 259,200 = 77,417.

Angle to be plotted = 21° — 40′ — 19′.

By applying this method to conversion all scales and constants can be converted into angles and plotted with the protractor.

In order to plot the square root scale opposite, it would only be necessary to divide each angle by 2 and plot the new angles. In this case the scale would cover 36° of the circle. This explanation will be very evident by comparing scales B and D on the instrument.

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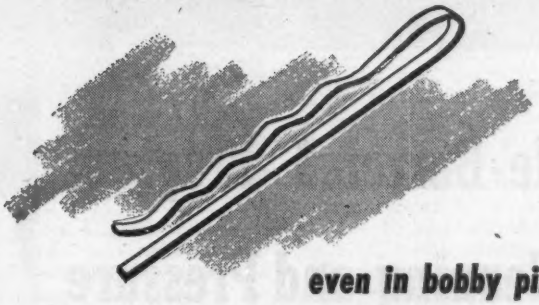

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This illustrates in a striking manner the small amount which the cost of steel plays in the ultimate cost of steel products. Any increases that have occurred in the price received by the steel producers are not important from an inflationary standpoint. ***Steel IS cheap.***

The average price of steel as obtained by the mills is a little over 3c per pound — about $60 per ton (based on weighted production of 9 major steel mill items, representing a substantial percentage of steel production in the United States.) Including the recently announced increases, steel has advanced only about ½c per pound over the last ten years.

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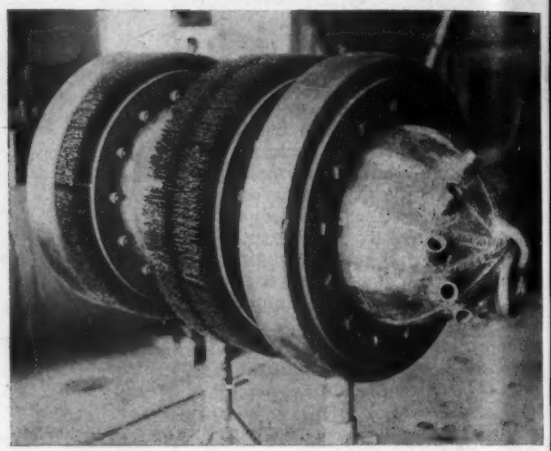
Left: Four-brush cleaner, placed in special inserter device, which is ready to be jacked into the pipe line

Below: View of three-brush cleaner showing nozzles at forward end



Double-Barreled Program For Cleaning and Pressure Testing Gas Pipe Lines

by D. K. Stephens

IN connection with the measures taken by Panhandle Eastern Pipe Line Co. in 1946 and 1947 for increasing the throughput of natural gas through existing lines transmitting from the Texas Panhandle to Detroit, the transmission pipe-line department has had a "double-barreled" program.

This has consisted of extensive interior cleaning of sections of the trunk line during the summer of 1946 and the testing of the entire main trunk line from Liberal, Kans., to Zionsville, Ind., during August 1947.

This article will discuss what was accomplished to achieve greater efficiency with economical cost and safe operation by improved methods and equipment. These include utilization of the advantages of two-way radio and airplane observation in conjunction with the work.

Cleaning

In the July 5-September 4, 1946, cleaning of 570 miles consisting of approximately 37 per cent of main line, between the Liberal, Kans., and Montezuma, Ind., compressor stations, the total cost of $97,984 amounted to $171.63 per mile. This is approximately $36 less per mile than the $207.43 per mile cost of cleaning in the previous major cleaning done in 1944. Lower costs were obtained in the face of the general increase in the cost of labor and supplies. Without hesitation the author asserts that 80 per cent of the saving was due to the use of two-way radio communication which made it possible to save about 20,000 miles of driving and to reduce the length of time that sections of the line were out of service. According to conservative estimates, $25,000 to $30,000 was saved on the job by using radio. This saving was accomplished by reducing overtime labor and by saving of gas, which would have been curtailed from sales, and by saving car mileage.

Previous flow-test data had indicated that by cleaning certain sections of lines in loops which showed low efficiency, it was possible to raise the over-all efficiency between Liberal and Montezuma by 10,000,000 cu. ft. per day with existing facilities. In the 1946 program all sections were cleaned which had an efficiency of 86 per cent or lower.

Operating the jack to force the cleaner into the pipe line

Blow joint at location where cleaner will be removed from the line. This joint is raised at a slight angle in order that the cleaner will clear the ditch when it comes out of the line. Openings, approximately 25 ft. from the end of the blow joint, release excessive pressure, thus reducing the speed of the cleaner after it passes them

Oil is fairly well distributed on the walls of the pipe the full length of all the loops, according to evidence obtained in examining joints removed from the line. Apparently, this oil does not affect the efficiency of loops that are up to or above design efficiency and on which no cleaning was necessary. Flow tests showed that all such loops were within a fraction of 1 per cent of what they were 16 to 18 months previously. Some had even increased in efficiency. However, loops that were dirty and had low efficiencies in 1944 and 1945 had declined further in efficiency at the time of the 1946 flow tests.

Pipe walls that have oil-saturated scale or other foreign matter on them are apt to accumulate additional dirt as time goes on. Oil in the lines from station to station makes it more difficult to clean since there is an absence of the abrasive effect on the pipe walls which is produced by the action of loosened scale and dirt as it is blown through the line when it is dry.

Since the time element will be a vital factor in any future cleaning operations, it is highly desirable to obtain satisfactory results by passing the go-devil only once through the pipe. A new design of go-devil now being developed by our organization has promise of cleaning thoroughly in one pass through the pipe.

The efficiency of the cleaned portion of each loop was increased from 2.1 to 13.0 per cent and averaged 6 per cent.

Some increase in efficiency was noticed on some sections of line that were not cleaned but which were opposite sections of the other line that were cleaned. It is thought that the increased velocity in these sections, while bypassing the opposite section, did a certain amount of cleaning. However, other sections that were not cleaned and which were not opposite sections being cleaned were found to be lower in some cases. This indicated that dirt was moved ahead and was deposited in sections with the low velocity, thus offsetting any over-all gain.

D. K. Stephens, superintendent of transmission lines, started with Panhandle Eastern Pipe Line Co. on main-line construction in 1930. Subsequently he was division superintendent until advancement to his present postion in 1938.

Dirty lines accumulate more dirt. Clean lines stay clean or improve.

An example of high efficiency may be cited in the Greensburg 85.9-mile loop. Over-all efficiency of sections in the loop cleaned was raised from 85 to 97 per cent while the efficiency of the entire loop was raised from 88 to 96 per cent. In several sections, efficiencies were increased as follows: from 81 to 104 per cent; 86 to 103 per cent; 87 to 100 per cent.

Testing

In the testing of the trunk line starting at Liberal station, Kans., on August 5, 1947, and proceeding through the remainder of the month to Zionsville station, Ind., pressure was raised to 750 psi. This test was to prepare for a program for operating at 700 psi.

The program called for testing a 85-90-mile interval between stations on alternate days.

For this testing, cars, pickups, trucks, and mechanized equipment from three districts were assembled, of which approximately 15 were equipped with two-way radio. These were placed at vital points along the route in the vicinity of road crossings, gate valves, etc. For the first time in Panhandle Eastern testing operations, an airplane, likewise equipped with two-way radio, patrolled the line during testing, flying at 500-ft. altitude on a course 500 ft. to windward. Furthermore, additional radio facilities were available in the cars of state highway patrol cars assigned to cooperate.

Since gate valves are numbered according to a uniform plan between stations, instructions were issued in advance which applied to each loop.

In the interest of safety, gate valves were handled remotely during testing by means of equipment for manipulating with a ¼-in. sand line operated by a winch at a distance of 500 ft. from the valve on the pipe line. Near each winch there was a gage connected to the line by 500 ft. of pressure hose. Section gate valves are 8 to 10 miles apart.

Emergency equipment included a back hoe, cat with bulldozer, welding equipment, air compressors, pumps, pipe line trucks, Dugas fire fighting equipment including asbestos suit.

In advance of the test, notifications were sent to railroads, electric power companies, and residents along the route; and precautions were taken to insure that during testing no one was closer than 500 ft. to the line.

In general, the highest pressures were applied to the first three sections, totaling approximately 24 miles on the discharge side of each station as well as the compressor station piping. A more or less "flat" pressure test was made on the first three sections and a "drop" pressure test on the following sections.

Experience of the company indicates that a consistent program of cleaning and testing in alternate years is advantageous for maintaining line efficiency for the high throughput required for meeting increasing market demands.

Plant-Built Scrapers

(Continued from page 237)

of pipe, was coupled to the end of the line. Friction stopped the scraper within a few feet after the pressure behind it was released by the slots.

In all 28 runs were made by the two scrapers through the various sections of the line. The shortest run was 0.48 miles, and the longest was 4.44 miles. No. 1 scraper traveled a total distance of 27 miles, and No. 2 scraper traveled 40 miles. Very little repair work was done on the scrapers. Approximately 3,300 gal. of dirt and fluid was removed by the scrapers, and calculations showed approximately 1,000,000 cu. ft. of gas was used to drive them.

Spot checks made under normal operating conditions during the winter of 1946-47 showed an average efficiency of 85 per cent, which when compared with the 60 per cent efficiency that existed previously, made the project worth while.

Pipe-Line Flow Formulas

(Continued from page 175)

pipe having a diameter of 0.33 ft., at least. Unless and until evidence to the contrary is adduced, therefore, the friction factor determined by experiments on drawn brass pipe may be accepted as the smooth-pipe friction factors.

Laminar and Turbulent Flow

During the past 30 years it has become customary to plot the logarithms of the smooth-pipe friction factors against the logarithms of the Reynolds numbers. This plot, now familiar to most engineers, has three regions, each corresponding to a different mode of flow. In the first region, extending to a Reynolds number of about 2,000, the plot is a straight line sloping downward from left to right, making 45° angles with the axis; this line corresponds to the laminar mode of flow. From a Reynolds number of 2,000 to a Reynolds number of 3,000 the curve is upward, and usually dashed; sometimes a band is shown rather than a line; this is the transition region, and corresponds to an unstable, fluctuating mode of flow. From a Reynolds number of 3,000 to the end of the graph the line slopes gradually downward, at first nearly straight, but with the slope getting closer to zero as the Reynolds number increases; this line corresponds to the turbulent mode of flow.

Formula for Pressure Gradient in Laminar Flow

The salient characteristic of laminar flow is indicated by its name. The fluid behaves as though it were arranged in concentric cylindrical laminas, or sheets, each sliding upon its neighbors, being dragged forward by the next innermost and being held back by the next outermost. There is of course some diffusion of molecules from one lamina to another, but no bulk transfer of fluid. The formula for the pressure gradient in the case of laminar flow can be derived readily from the definition of viscosity, which is:

$$\tau = \mu \, (du/dr) \qquad (12)$$

where

τ = the force in the flow direction per unit area of fluid surface parallel to the flow direction, in pounds-force per square foot,

u = the velocity of the fluid at the point where the force is applied, in feet per second,

r = the distance to the point where the force is applied from a reference point, this distance being perpendicular to the flow direction, in feet, and

du/dr = the rate of increase in u with r, in reciprocal seconds.

Taking the reference point on the pipe axis, and considering a lamina of length δL and thickness δr, we note that there are forces acting on its four surfaces, and that these are in balance. The force on the outside cylindrical surface is acting to stop the forward movement of the lamina, as is the force due to the pressure on the downstream end, while the force on the inside cylindrical surface and that due to the pressure on the upstream end are acting to speed the forward movement. Equating the difference between the forces on the two cylindrical surfaces to the difference between the forces on the two ends, forces in the flow direction being positive:

$$[d(2\pi r \tau \delta L)/dr] \, \delta r = [d(2\pi r \delta r P)/dL] \, \delta L \qquad (13)$$

This simplifies to:

$$d(r\tau)/dr = r(dP/dL) \qquad (14)$$

which is integrated with respect to r by:

$$r\tau = \frac{r^2 \, (dp/dL)}{2} + C_1 \qquad (15)$$

Since the flow extends to the pipe axis, where r is zero, the constant C_1 must be zero, and

$$\tau = r \, (dP/dL)/2 \qquad (16)$$

Combining with Formula 12:

$$\mu \, (du/dr) = r \, (dP/dL)/2 \qquad (17)$$

which is integrated with respect to r by:

$$u = (r^2/4\mu) \, (dP/dL) + C_2 \qquad (18)$$

Assuming that the velocity is zero at the wall, where r is D/2, the constant C_2 is:

$$(-D^2/16\mu) \, (dP/dL) \text{ and}$$

$$u = (-D^2/16\mu + r^2/4\mu) \, (dP/dL) \qquad (19)$$

Formula 19 shows that with laminar flow and zero velocity at the wall the velocity is $(-D^2/16\mu) \, (dP/dL)$ at the axis and decreases with the square of the distance from the axis.

To get the flow rate we write:

$$\delta Q = 2\pi r \, \delta r \, u \qquad (20)$$

where

δQ = the flow rate through the lamina of thickness δr, in cubic feet per second.

Making the lamina thin, in the limit:

$$dQ = 2\pi r \, u \, dr \qquad (21)$$

which, combining with Formula 19, makes:

$$dQ = 2\pi \left(\frac{-r D^2 \, dr}{16\mu} + \frac{r^3 \, dr}{4\mu}\right)\left(-\frac{dP}{dL}\right) \qquad (22)$$

which, integrated from pipe axis to wall, gives:

$$Q = -(\pi D^4/128\mu) \, (dP/dL) \qquad (23)$$

Formula 23 is Poiseuille's law, discovered by experiment before it was derived mathematically. Its validity has been established by many investigators.

Introducing V through Formula 2:

$$V = -(D^2/32\mu) \, (dP/dL) \qquad (24)$$

or

$$-(dP/dL) = 32\mu V/D^2 \qquad (25)$$

Comparing this with Formula 8:

$$f V^2 \rho/2D = 32\mu V/D^2 \qquad (26)$$

whence

$$f = 64\mu/D V \rho = 64/N_R \qquad (27)$$

In the case of laminar flow, therefore, we may use Formula 25 directly to solve for (dP/dL), or we may use Formula 27 to calculate f from N_R, then use Formula 8. It will be noted that Formula 25 does not contain the density of the fluid; if the flow is laminar, the pipe friction is independent of the density. However, the density does enter into the Reynolds number, so that it is necessary to know the density in order to calculate the Reynolds number; or at least to know the maximum value the density may have, to calculate that the Reynolds number is not too great for laminar flow to be stable.

Calculations to Establish That Flow Is Laminar

If the pipe diameter, flow velocity, fluid viscosity, and fluid density are known, and the pressure gradient is to be calculated, the procedure is to calculate N_R and if this does not exceed 2,000, the flow is laminar, and Formula 25 can be used to calculate (dP/dL); or f can be calculated by Formula 27, and used in Formula 8. However, the problem may be to calculate the flow velocity which will be provided by a stipulated pressure gradient; or the diameter necessary to get a particular flow rate with a certain pressure gradient. In neither of these cases can the value of N_R be calculated immediately, so that it is necessary to establish that the flow is laminar by other calculations.

If the flow is laminar the flow velocity V may be calculated by Formula 24, or by Formula 9 if C_f is known. Combining Formulas 24 and 9 to eliminate V and solving for C_f, we have for laminar flow:

$$C_f = [2 D^2 \, (-dP/dL) \, \rho]^{0.5}/64\mu \qquad (28)$$

Formula 27 combined with Formula 5 yields for laminar flow:

$$C_f = (N_R/64)^{0.5} = (D V \rho/64\mu)^{0.5} \qquad (29)$$

Taking 2,000 as the maximum Reynolds number for laminar flow, the corresponding maximum value of the flow coefficient C_f is $(2{,}000/64)^{0.5}$, which is 5.6. Then if V is to be calculated, and it is suspected that the conditions are consistent with laminar

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flow, Formula 28 should be used to calculate C_f. If a value of 5.6 or less is found, the flow will be laminar, and the value of C_f found can be used in Formula 9, or Formula 24 may be used. If Formula 28 yields a value higher than 5.6 the flow is not laminar, and the procedure to be used is that given below for turbulent-flow calculations.

Combining Formulas 2 and 9 we obtain:

$$Q = C_f \pi D^3 [D (-dP/dL) (8\rho)]^{0.5} \quad (30)$$

This can be combined with Formula 28 to eliminate D, yielding another formula for C_f:

$$C_f = \left[\frac{(Q/\pi)^3 (-dP/dL) (8\rho)^4}{(128\mu)^5}\right]^{0.125} \quad (31)$$

Formula 31 may be used to calculate whether conditions are consistent with laminar flow if the diameter is not known; if C_f as calculated by Formula 31 is 5.6 or less, the flow is laminar.

For example, if an oil having a density of 1.8 lb.-force sec.^{2}/ft.^{4} and a viscosity of 6×10^{-4} lb.-force sec./ft.^{2} is flowing through a pipe having an inside diameter of 0.5 ft. at a flow velocity of 1.2 ft. per sec., by Formula 29:

$$C_f = \left(\frac{0.5 \times 1.2 \times 1.8}{64 \times 6 \times 10^{-4}}\right)^{0.5} = 5.3$$

so that the flow is laminar.

If the same oil is flowing through the same pipe, but at such a rate that the pressure gradient is —0.1 lb.-force/ft.^{3}, by Formula 28:

$$C_f = \frac{[2 \times 0.5^3 (0.1) \times 1.8]^{0.5}}{64 \times 6 \times 10^{-4}} = 5.54$$

and again the flow is laminar.

If the same oil is flowing through a pipe at the rate of 0.3 ft.^{3}/sec., and the pressure gradient is —0.1 lb.-force/ft.^{3}, by Formula 31:

$$C_f = \left[\frac{(0.3/3.14)^3 (0.1) (8 \times 1.8)^4}{(128 \times 6 \times 10^{-4})^5}\right]^{0.125} = 5.83$$

which means the flow is in the transition region.

Laminar Flow of Ideal Gas at Constant Temperature

The density of an ideal gas is directly proportional to its pressure, at constant temperature, while the viscosity of an ideal gas is independent of pressure. If gas is flowing steadily through a pipe, the mass of gas leaving the end of the pipe in 1 second must be the same as the mass of gas entering the beginning of the pipe in 1 second. Since there is a pressure drop through the pipe, the gas entering the pipe is under a higher pressure than the gas leaving the pipe, and its density is proportionately higher. The number of cubic feet leaving in 1 second is greater than the number of cubic feet entering, and all along the pipe the flow rate and flow velocity are increasing. Thus for any location along the pipe:

$$M = Q\rho = Q k P \quad (32)$$

where

M = the mass flow rate, in pound-force seconds, and

k = a constant characteristic of the gas and the temperature, equal numerically to the density at a pressure of 1 pound-force per square foot, and being measured in seconds squared per square foot.

Combining Formulas 23 and 32:

$$M = -(k \pi D^4/128\mu) (P\, dP/dL) \quad (33)$$

which is integrated from beginning to end of the pipe by:

$$M = k \pi D^4 (P_b^2 - P_e^2)/256 \mu L \quad (34)$$

which is valid for laminar flow of an ideal gas at constant temperature, except for a very minor correction for the change in kinetic energy.

To establish that the flow is laminar it must be shown that N_R is not over 2,000, or that C_f calculated by Formula 28, 29, or 31 is not over 5.6. Combining Formulas 2 and 32:

$$V = 4M/\pi D^2 \rho \quad (35)$$

so that Formula 29 can be replaced by:

$$C_f = (N_R/64)^{0.5} = (M/16 \pi D \mu)^{0.5} \quad (36)$$

Writing kP for ρ, Formula 28 becomes:

$$C_f = [2 D^3 (-P\, dP/dL) k]^{0.5}/64\mu \quad (37)$$

which is integrated from beginning to end of the pipe by:

$$C_f = [k D^3 (P_b^2 - P_e^2)/L]^{0.5}/64\mu \quad (38)$$

Combining Formulas 31 and 32 to eliminate Q and ρ:

$$C_f = \left[\frac{(M/\pi kP)^3 (-dP/dL) (8kP)^4}{(128\mu)^5}\right]^{0.125} \quad (39)$$

which is integrated from beginning to end of the pipe by:

$$8C_f = \left[\frac{k (M/\pi)^3 (P_b^2 - P_e^2)}{\mu^5 L}\right]^{0.125} \quad (40)$$

Thus to establish laminar flow of a gas, the value of C_f may be calculated by Formula 36, 38, or 40, depending upon the information available, and if C_f is not greater than 5.6, the flow is laminar.

For example, if the typical natural gas mentioned above, for which ρ is 1.4×10^{-3} lb.-force sec.^{2}/ft.^{4} at atmospheric pressure (2,106 lb.-force/ft.^{2}) and μ is 2.1×10^{-7} lb.-force sec./ft.^{2}, flows through a pipe having an inside diameter of 0.01 ft., at a mass flow rate of 1.65×10^{-6} lb.-force sec., the value of C_f calculated by Formula 36 is:

$$C_f = \left(\frac{1.65 \times 10^{-6}}{16 \times 3.14 \times 0.01 \times 2.1 \times 10^{-7}}\right)^{0.5} = 3.96$$

so that the flow is laminar. Now by Formula 34 we may calculate, with k taken as $1.4 \times 10^{-3}/2{,}106$, or 6.65×10^{-7}, that:

$$(P_b^2 - P_e^2)/L = \frac{256 \times 2.1 \times 10^{-7} \times 1.65 \times 10^{-6}}{3.14 \times 0.01^4 \times 6.65 \times 10^{-7}} = 4{,}250$$

If $(P_b^2 - P_e^2)/L$ is given as 4,250, and M is unknown, we establish that the flow is laminar by Formula 38:

$$C_f = \frac{[6.65 \times 10^{-7} \times 0.01^3 \times 4{,}250]^{0.5}}{64 \times 2.1 \times 10^{-7}} = 3.96$$

If D is the unknown, we use Formula 40:

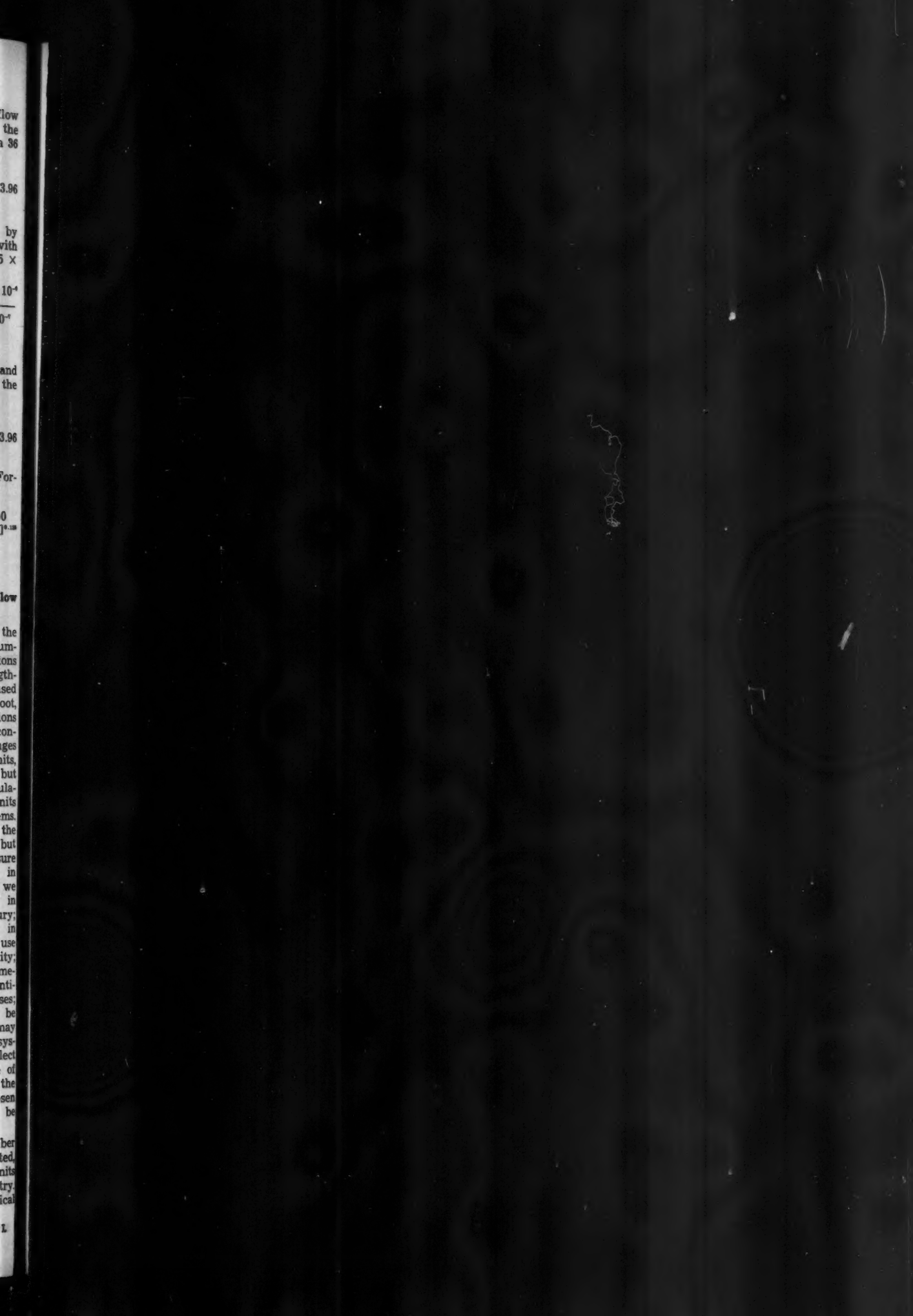
$$8C_f \left[\frac{6.65 \times 10^{-7} (1.65 \times 10^{-6}/3.14)^3 \times 4{,}250}{(2.1 \times 10^{-7})^5}\right]^{0.125}$$

$$C_f = 3.96$$

Practical Formulas for Laminar Flow of Liquids

In the formulas given above the symbols represent dimensionless numbers, or quantities whose dimensions are expressed in the force-length-time system, and the only units used have been the pound-force, the foot, the second, and various combinations of these three, chosen to form a consistent system. There are advantages in using a consistent system of units, particularly for deriving formulas, but for many measurements and calculations it is convenient to use units which belong to different systems. Thus we commonly measure the length of a joint of pipe in feet, but its diameter in inches; our pressure gages are usually calibrated in pounds-force per square inch, but we also use manometers graduated in inches of water or inches of mercury; frequently we express densities in pounds-mass per cubic foot, or use specific gravity rather than density; the viscosities of liquids are sometimes expressed in poises or centipoises, and of gases in micropoises; and many other examples could be given. For flow calculations we may convert all quantities to the systematic unit basis; or we may select a set of units for a certain type of calculation, and then transform the formulas to the basis of the chosen units, thus deriving what may be called practical formulas.

There is no limit to the number of sets of units which can be selected, and no general agreement on all units in a set even in one trade or industry. Since not all the possible practical



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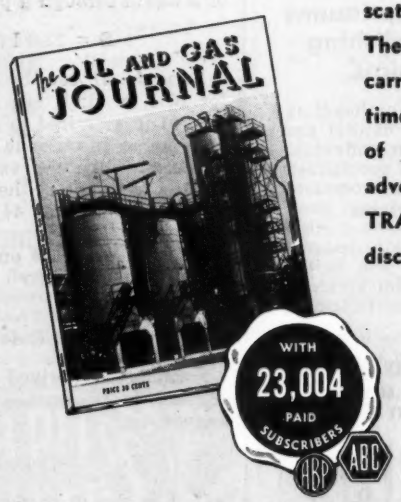

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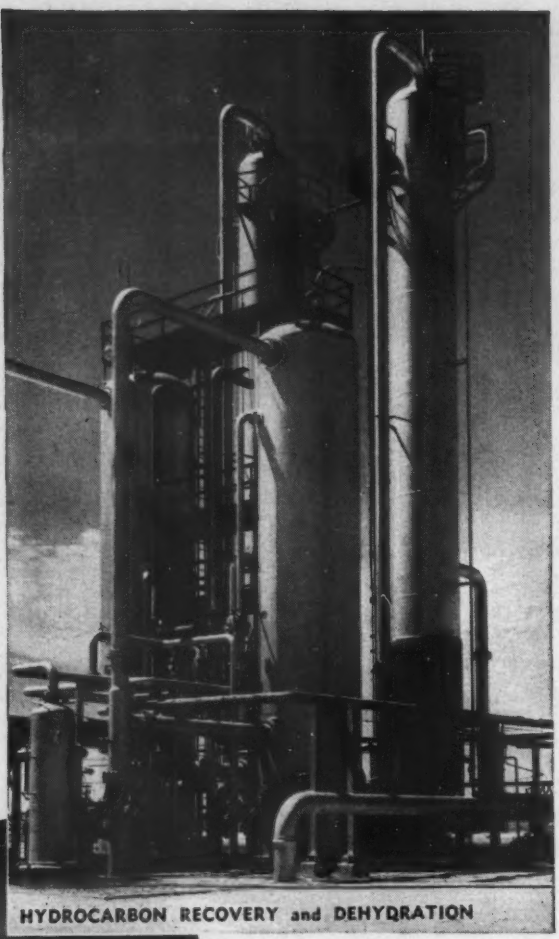

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formulas can be included, the present work will be restricted to those based on two sets of units, one for liquids and the other for gases. As the pipe lines of the oil and gas industry are the particular concern of this work, units used in that industry will be selected, but it is freely admitted that other units might have been chosen in some cases with as good reason.

For liquids, assumed not to be compressible, the formulas given above, or some of them, will be transformed into practical formulas which will employ the following symbols:

B = the flow rate, in barrels per day.
I = the negative pressure gradient, or rate of decrease of pressure with distance from the beginning of the pipe, in pounds-force per square inch per mile.
s = the specific gravity referred to water at 60° F., or the ratio of the density of the fluid to the density of water at 60° F.
d = the inside diameter of the pipe, in inches.
z = the viscosity of the liquid, in centipoises.

In making the transformations the standard conversion factors are used, such as 12 in. = 1 ft., etc., to calculate the conversion factors for the flow variables, as follows:

$$6.50 \times 10^{-6}\ B = Q$$
$$2.73 \times 10^{-9}\ I = (-dP/dL)$$
$$1.94\ s = \rho$$
$$0.0833\ d = D$$
$$2.09 \times 10^{-5}\ z = \mu$$

Applying these conversion factors to Formula 23, there is obtained a practical formula for the laminar flow of a liquid through a pipe:

$$B = 23.8\ I\ d^4/z \qquad (41)$$

Formula 41 can be solved readily for B, I, or d; it can also be solved for z if it is desired to use a pipe as a viscometer. In order to justify the use of Formula 41, the value of C_r calculated from one of the following formulas, 42, 43, and 44, must not be greater than 5.6.

Formula 42 is the one to use when I is unknown; derived from Formula 29, it is:

$$C_r = (N_R/64)^{0.5} = (1.44\ B\ s/d\ z)^{0.5} \qquad (42)$$

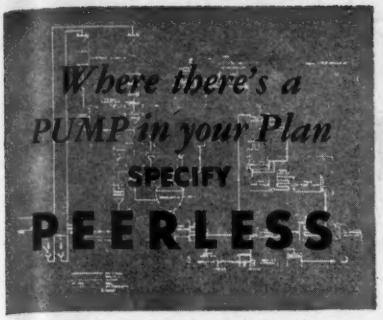
Formula 43, derived from Formula 28, and to be used when B is unknown, is:

$$C_r = (34.2\ d^3\ s\ I/z^2)^{0.5} \qquad (43)$$

If d is the unknown, use the formula derived from Formula 31; this is Formula 44:

$$C_r = (102\ B^2\ I\ s^4/z^2)^{0.125} \qquad (44)$$

For example, if an oil having a specific gravity of 0.95 and a viscosity of



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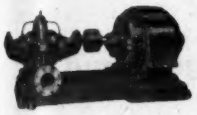

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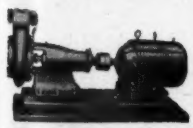

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30 centipoises is flowing through a 6-in. i.d. pipe at the rate of 3,600 bbl. per day, by Formula 42:

$$C_f = (1.44 \times 3{,}600 \times 0.95/6 \times 30)^{0.5}$$

$$= 5.23$$

so that the flow is laminar; then by Formula 41:

$$I = (3{,}600 \times 30) \div (23.8 \times 6^4) = 3.5$$

If the problem were to calculate the flow rate, having been given that the pressure dropped 3.5 psi. per mile, the stability of laminar flow would be established by Formula 43:

$$C_f = (34.2 \times 6^3 \times 0.95 \times 3.5/30^2)^{0.5}$$

$$= 5.23$$

If it were required to calculate the pipe diameter needed to move 3,600 bbl. per day with a pressure drop of 3.5 psi. per mile, Formula 44 would be used:

$$C_f = (102 \times 3{,}600^3 \times 3.5 \times 0.95^4/30^2)^{0.125}$$

$$= 5.23$$

Laminar flow is probable with the more viscous crudes and with residual oils, improbable with kerosine and lighter products.

Practical Formulas for Laminar Flow of Ideal Gases at Constant Temperature

The symbols to be used in the practical formulas for laminar flow of ideal gases at constant temperature are as follows:

Q_a = flow rate in cubic feet (measured at 14.696 psia. and 60° F.) per day.
p_b = the pressure at the beginning of the pipe, in pounds-force per square inch absolute.
p_e = the pressure at the end of the pipe, in pounds-force per square inch absolute.
l = the length of the pipe, in miles.
$F = (p_b^2 - p_e^2)/1$.
G = the specific gravity referred to air at the same temperature.
T = the temperature of the gas in degrees Rankine.
d = the inside diameter of the pipe, in inches.

The conversion factors required for the transformations are:

$$M = 2.74 \times 10^{-3} Q_a G$$
$$k = 5.83 \times 10^{-4} G/T$$
$$D = 0.0833\ d$$
$$(P_b^2 - P_e^2)/L = 3.93\ F$$

The practical formula for laminar flow of a gas through a pipe, obtained by applying the conversion factors to Formula 34, is:

$$Q_a = 0.0493\ F\ d^4/T\mu \qquad (45)$$

While Formula 45 can be solved for

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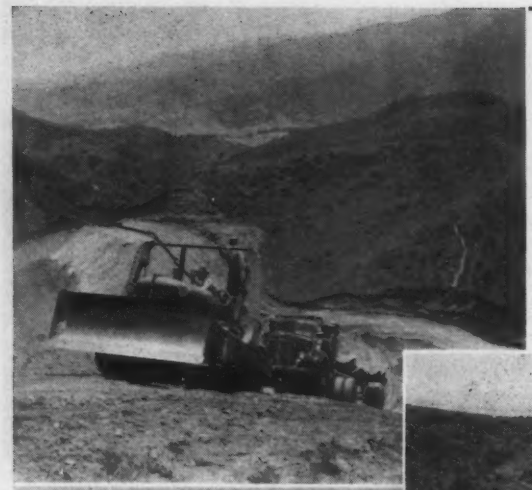

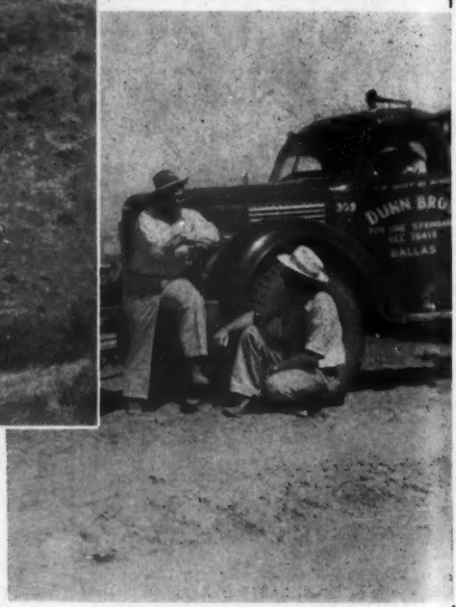

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F, d, T, or μ as well as for Q_d, it should only be used if the flow is laminar. This will be the case if C_f is calculated to be 5.6 or less by Formula 46, 47, or 48. Formula 46, derived from Formula 36, is to be used when F is the unknown; it is:

$$C_f = (6.56 \times 10^{-9}\ Q_d\ G/d\ \mu)^{0.5} \quad (46)$$

If Q_d is the unknown, use Formula 47 derived from Formula 38; it is:

$$C_f = (3.24 \times 10^{-10}\ G\ F\ d^3/T\ \mu^2)^{0.5} \quad (48)$$

If the unknown is d, the formula to use is one derived from Formula 40; it is Formula 48:

$$C_f = (9.13 \times 10^{-35}\ Q_d^2\ G^4\ F/T\ \mu^5)^{0.125} \quad (48)$$

For example, if gas having a specific gravity of 0.6 and a viscosity of 2×10^{-7} lb.-force sec./ft.^{2} is flowing at 60° F. (520° Rankine) through a pipe having an inside diameter of 0.12 in. at the rate of 100 cu. ft. per day, by Formula 46:

$$C_f = \left(\frac{6.56 \times 10^{-9} \times 100 \times 0.6}{0.12 \times 2 \times 10^{-7}}\right)^{0.5} = 4.05$$

so that the flow is laminar; then by Formula 45:

$$F = \frac{100 \times 520 \times 2 \times 10^{-7}}{0.0493 \times 0.12^4} = 1{,}020$$

If F had been given as 1,020 and Q_d was to be calculated, it would have been necessary to use Formula 47:

$$C_f = \left(\frac{3.24 \times 10^{-10} \times 0.6 \times 1{,}020 \times 0.12^3}{520 \times 2^3 \times 10^{-14}}\right)^{0.5} = 4.05$$

while if F and Q_d had been given, and d was to be calculated, then by Formula 48:

$$C_f = \left(\frac{9.13 \times 10^{-35} \times 100^2 \times 0.6^4 \times 1{,}020}{520 \times 2^5 \times 10^{-35}}\right)^{0.125} = 4.05$$

Laminar flow of gases is probable only with small flow rates and small pipe.

Laminar Flow in Pipe Lines; Pipe-Line Efficiency

The actual flow rate for laminar flow in pipe lines will almost always be less than calculated by Formula 41 for liquids, or by Formula 45 for gases; or the pressure difference required will be greater; or the diameter required will be greater. In rare instances roughness of the pipe may be partly responsible for the difference between calculated and measured results; however, in most cases the pipe is smooth, but there is additional friction due to joints, bends, fittings, and so forth.

It is possible to make butt joints in such a way that the surface is substantially continuous from one length of pipe to the next, but this is usually not practical, so that frequently there will be either a groove or a ridge wherever two lengths of pipe are joined. The fluid has to move at right angles to the pipe axis in passing such a joint, with the result that the flow pattern is changed. After traveling some distance along the pipe, the laminar flow pattern is reestablished, but the friction is greater where the flow pattern is not laminar.

Changes in flow direction, such as caused by an elbow or a pipe bend, also disturb the flow pattern, and the disturbance persists for some distance downstream from its origin, becoming progressively less.

The additional resistance to flow depends upon the frequency of such disturbing elements, and upon the severity of the disturbances. For ordinary good construction they may reduce the flow rate 5 to 10 per cent. The ratio of the actual flow rate in a pipe line to the flow rate calculated for a pipe line constructed with smooth pipe and containing no disturbing elements, is called the efficiency of the pipe line. If the conditions are such that laminar flow should be stable, the efficiency is the ratio of the actual flow rate to the flow rate calculated by Formula 41 or Formula 45.

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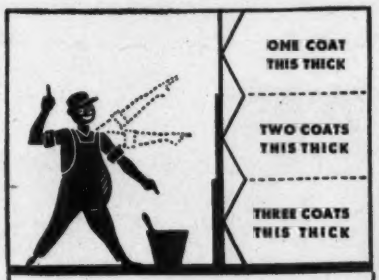

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Early Pipe-Line Batching

THE transportation of refined petroleum products by pipe line is not new. This statement may come as a surprise to a great many people, many of them within the oil industry, who have looked upon the batching of several refined petroleum products through the same line as a new development. The first products line of authentic record was built by the United States Pipe Line Co. in 1892 and remained in intermittent service until 1926. It was constructed of 4-in. and 5-in. pipe and extended from Titusville to Wilkesbarre, Pa., a distance of about 260 miles. In 1902, the line was continued on to Marcus Hook, Pa., some 100 miles further. The system included seven pumping stations and two terminals.

This information has been furnished by E. A. Birge, superintendent, eastern division, Plantation Pipe Line Co., who gives credit to Floyd E. Warterfield, Jr., president, Oklahoma Engineering Co., for calling his attention to the fact that the products pipe line industry generally has overlooked the significance of the pioneering operations of the United States Pipe Line project. Birge was concerned with these early operations in connection with the comprehensive study of the technique of batch control which he discusses in an article published in this issue, beginning on page 176.

The following is quoted from The Oil Well Driller, published in 1905:

"The independents laid a pipe line to transport refined oil from Oil City through Titusville and Warren, Bradford and Wilkesbarre, Pa., to Hampton Junction, N. J., for the purpose of reaching New York harbor. That line has been in operation 4 years, and has transported millions of barrels of refined oil without condemnation of a single barrel.

"Three different grades of oil (refined) are transported through the same line. They push out the poorer grade with a better, and it is turned into its own tank by means of a valve. They run that second grade until they have transported the amount desired; then put in a third grade until they have transported the amount desired of that, and then repeat the process.

"In pumping the oil along the line it does not mix for a distance of 50 ft.; though, of course, that poorer grade mixes with the better for a short distance in the line."

So far as can be determined from available records, only kerosine or "refined oils" were pumped through the United States Pipe Line system. The kerosine was of three established grades, 110° prime white; 120° standard white; and 120° water white. Documented records of the early gasoline lines are not available, but it is known that several small, short lines were laid in California around 1900. In 1917 Midwest Refining Co. laid a 40-mile, 3-in. gasoline line from Salt Creek to Casper. Several casinghead gasoline and distillate lines were laid near Boynton, Okla., in 1920. These few brief historical references are sufficient to establish the very early existence of refined-oil pipe lines and furthermore that "batching" is not a recent innovation.

Beginning with 1930, products pipe lines began to have a wider commercial importance in the marketing distribution of motor fuels and other refined oils. By the close of 1945, more than 15,000 miles of refined-oil lines were in use, but it is only within the past 5 years that the economic advantages of "batching" have been fully appreciated.

We sometimes marvel at modern progress and development. The last paragraph in the Oil Well Driller article indicates the pipe liners almost half a century ago proved that batching products through a single line was practical; and we are just now coming to appreciate it.

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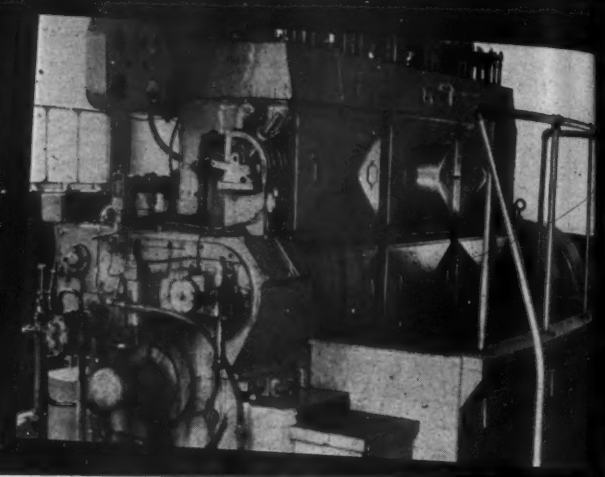

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Contamination Control

(Continued from page 179)

kerosine would be contaminated because of this loop. The contamination due to this loop, alone, would amount to 1,478 bbl. This is about twice the **normal** spread through the entire Plantation Pipe Line system. Of course, if both legs of the loop were exactly the same size, the same length, and had the same degree of roughness along the inner pipe walls, the problem would not be so serious. Such a condition could not easily be maintained, however.

This does not infer that pipe lines, already built, which contain loops, are hopeless as potential products lines. By installing gate valves and meters, or some similar arrangement, to check and control the flow, the two lines could be synchronized. However, if the loops were long and of different diameters, it would probably be impracticable to try to synchronize them.

Concerning (3), on crude lines, where contamination is not a vital problem, usually each station pumps into a tank at the downstream station. The downstream station takes suction from the same tank for its pumps. If one station pumps more than the other, the tank receives the excess or supplies the deficit from its stock. It "floats" on the line. Naturally, it is necessary to carry some stock in this tank. Such a tank, on a products line, would be a source of prohibitive contamination.

Usually, pipe lines designed for operation with float tanks have low-pressure fittings on the incoming lines. Such lines are not easily converted to closed-line operation because of these low-pressure fittings. In closed-line operation, when pumping past a shutdown station, the pressure at the idle station would be too high for low-pressure fittings. Some crude lines have successfully run special batches of products, however, by closing off the float tanks and connecting pressure-relief valves to relieve pressure into the float tanks in the event of pressure surges. Any product going to the float tanks simply remains there and is absorbed by the next product pumped. It would, of course, be impossible to handle a variety of products in such a manner.

A plan of Plantation's typical station is shown in Fig. 7, as an illustration of (4), streamlined station piping. In this design dead spots which do not flush readily are minimized.

Considering item (5), products pipe lines having pumping equipment designed so that a quantity of the product being handled drains from pump glands into water separators and sumps, to be pumped back in the stream, must be equipped with a sump which can be pumped completely dry and with a suitable sump pump which can be run during the change from one product to another. In doing so, all the contaminating product draining into the sump will be returned to the "contamination plug" between the two products in the pipe line. A low-speed, reciprocating pump has been found most satisfactory for this sump-pump service. During batch changes in the line, the pump must be operated only partly filled with fluid, in order to keep the drainage moving from the sump back into the stream. A high-speed centrifugal pump would not be well suited for this work. The sump is usually designed so the sump pump takes suction from a small "top-hat" sump in the bottom of the main sump. Pump manufacturers are now trying out mechanical seals which eliminate this drainage from pump glands, and this factor is declining in importance with the development of these seals.

When drainage from pumps and other equipment is run through water separators, before going into the sump, it has been found advisable to provide separate compartments in the water separator for gasolines and fuels. This avoids contamination on changes from one product to another.

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through which several different petroleum products are handled for several different companies, it is the practice to pump the products in "cycles." A cycle is the period of time during which each type of product for each shipper is pumped. A cycle is established for each product, then the product is pumped once during each cycle for each shipper offering it. As an example, suppose a given pipe line handled premium and housebrand gasoline, kerosine, and diesel fuel for each of three companies, A, B, and C. Assume gasoline is pumped on 5-day cycles and kerosine and diesel fuel are pumped on 20-day cycles. As illustrated in Fig. 1, during the first 5-day cycle a 6⅔-day supply of premium and housebrand for each of the three companies would be pumped. The products for each company would be pumped in a definite order and would maintain the same relative position in each cycle. During the second and third 5-day periods, the first "cycle" would be repeated, exactly. At the end of the third 5-day cycle, a 20-day supply of premium and housebrand gasoline for each of the three companies will have been put into the line and staggered so that deliveries to each company will be made at approximate 5-day intervals. During the fourth 5-day period, a 20-day supply of kerosine and diesel fuel for each company will be pumped. The 5-day surplus supply of gasoline built up by the shippers during the first 15 days will carry them through the fourth cycle, during which no gasoline is pumped. In this instance the cycle for gasoline is said to be 5 days, and for kerosine and diesel fuel, 20 days.

Proper Product Cycle

Correctly estimating the proper cycle for each product is an important factor in the design of a products pipe line and the terminal facilities. This will be taken up in more detail later.

Having decided upon the cycle for each product, the next step is to determine the most advantageous position for each product, with respect to the other products in the pumping schedule, and the size of batches. The basic principle is to **put those products next to each other, the mixture of which will be disposable into one or the other product, or into some other product being currently handled.**

A batch of a product is defined as that quantity of the given product which is pumped into the line in one continuous unit. It will be separated from other batches of the same product by the batches of similar or dissimilar products belonging to the same or other shippers. Batches vary in size from a few hundred barrels (buffer batch) to hundreds of thousands of barrels. Buffer batches are frequently inserted to separate two products, a mixture of which would be difficult to dispose of as contamination.

Fig. 1 illustrates the principle of batching products in cycles. It shows, also, the principle of buffer batches. It will be noted that a buffer batch of kerosine has been inserted between gasoline and diesel fuel. Other principles, most of which are illustrated by Fig. 1, are:

1. Contamination between housebrand and premium gasoline can usually be split both ways with no degradation of product.
2. Tractor fuel-gasoline contamination, usually, must be cut out and blended to gasoline.
3. Tractor fuel-kerosine contamination, ordinarily, can be cut directly to tractor fuel.
4. Contamination between kerosine and diesel fuel can be cut to the diesel fuel, with certain limits, without degrading the diesel fuel.
5. Contamination between gasoline and diesel fuel would not blend readily with either gasoline or diesel fuel; therefore, a "buffer" batch of kerosine is put between them. This buffer can be cut in the middle and disposed of to the gasoline and diesel fuel respectively. The kerosine-diesel fuel mixture being cut to the diesel fuel and the kerosine-gasoline mixture being blended off into the gasoline.
6. Contamination between gasoline

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and kerosine can be cut out and blended off in small percentage to gasoline.

7. Contamination between two brands of housebrand gasolines, or two brands of kerosine or diesels, can be split both ways with no degrading of product.

This discussion only illustrates the principle in general. There are numerous state, federal, and manufacturers' specifications which must be considered in safeguarding the physical properties of the products.

Heart-cut deliveries.—Experience has taught that the spread of contamination between two products in the pipe line is much more rapid at the beginning and diminishes gradually with distance traveled. For this reason, it is advisable to make "heart-cut" deliveries from a batch at intermediate terminals and allow the contamination on either end of the batch to go undisturbed to the last terminal for the product. The term heart-cut implies that the delivery is made from pure products in the heart of the batch.

With proper terminal design, heart-cut deliveries, and favorable distribution of products, contamination tanks are needed **only at the final terminal** for that product. The size of contamination tanks at the last terminal for a given product should be based upon the amount of contamination expected, as estimated by the method developed later in this article. The number of contamination tanks depends upon the different types of contamination to be cut out. It is sometimes advisable to have several contamination tanks at a point where, say, both kerosine-diesel fuel contamination and kerosine-gasoline contamination must be set out. The mixing of both combinations in a common tank would complicate disposal of the contamination.

At stations.—It is found advisable to set up definite operating procedures at stations to insure proper flushing of pockets in the station piping, shutdown units, sump and water separators, etc., before the arrival of an easily contaminated product, such as kerosine. As an example, Plantation's established procedure is, in effect, as follows. Before the arrival of a batch of kerosine, a station must:

1. Clean one hay tank* and hold it out of service to be placed in service for the kerosine. (This is a precaution against the stream "channeling" through the hay and feeding gasoline into the stream from pockets in the saturated hay.)

2. Direct the incoming stream through the scraper traps. (To eliminate pockets formed by the scraper-trap bypass.)

3. Block off and drain the station bypass and pump the contents from the sump into the gasoline stream before the kerosine arrives. (Eliminates a pocket.)

4. If a unit is down, the stream is flushed through the idle unit during the change from gasoline to kerosine in order to remove all the gasoline from the system.

5. All takeoff lines, meter calibration lines, strainers, etc., are drained of gasoline and the gasoline is pumped from the pump to the line before kerosine arrives.

6. The sump is kept clear of products when the kerosine batch is due; and upon the first sign of kerosine, the sump pump is put into operation and is run completely through the change from gasoline to kerosine. This keeps the drainage from pump glands, gravitometers, etc., going into the contamination plug between the two products.

It has proved advantageous to write these procedures out in detail in an

*A hay tank is a horizontal, cylindrical tank, usually 36 in. in diameter and 16 ft. in length, equipped with a core element containing excelsior (hay). The stream enters one end of this hay tank, loses velocity because of the relatively large diameter of the hay tank, and is forced to go through the hay in the core in order to leave through an outlet at the top of the tank. The hay tank is designed to remove water and sediment. Each station on Plantation has two of these tanks. They can be run separately or in parallel.

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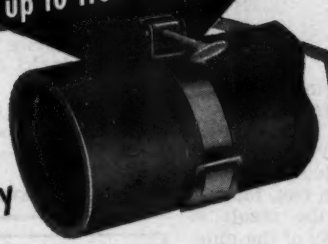

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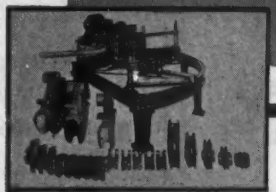

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operations manual, so they become routine. The efficiency with which they are carried out governs the amount of "induced" contamination, i.e., the quantity of contamination over and above the theoretical normal spread through a similar system with no contamination points. On Plantation's main line, with 431.6 miles of 12-in. and 356.8 miles of 10-in. and 28 stations, this induced spread adds approximately 11 per cent to the theoretical "normal" spread. A means of calculating the normal spread of contamination is given later in this article.

Normal Contamination

The "normal spread" of contamination between two products is believed to be a function of several factors, chief among which are velocity, differential density between the two products, viscosity, and probably the pipe friction factor. The exact relationship of each factor has not, as yet, been determined.

In collaboration with William J. Curry, of Shell Products Pipe Line Co., East Chicago, Ind., a series of tests were made on Plantation, in 1943, wherein the spread of contamination between various products was recorded; and the curves shown on Fig. 2 were derived from the data taken. For these curves, the spread of contamination, in feet, was plotted against the distance, in feet, traveled through the pipe line. In this manner it was possible to derive curves which would apply to any size of pipe. The equations for the two curves described by Fig. 2 are:

For gasoline-kerosine:

$$Y = 1.93\ X^{0.520}$$

For gasoline-gasoline:

$$Y = 1.84\ X^{0.462}$$

wherein:
X = distance traveled in feet
Y = contamination spread in feet

Having determined, by use of these equations, the anticipated spread of normal contamination, in feet, for any given length of line, the result is multiplied by the capacity of the pipe, in barrels per foot, to convert the spread to barrels. Table 1 shows the capacity per foot of several sizes of pipe and indicates a convenient method of obtaining the capacity, in barrels, of a given length of line. By making use of the conversion curves on Fig. 2, this can be done directly, as indicated in the example given on Fig. 2.

The curves of Fig. 2 represents the spread of contamination in three experimental cases between products of different physical characteristics. It is not to be interpreted that the two curves of Fig. 2 will indicate the spread of contamination between any two products. They will, however, indicate the order of contamination between two petroleum products whose physical differences are similar to the products involved in the experiments recorded by Fig. 2. Work is being done toward determining mathematically the part played by each factor, in the spread of contamination; and it is felt that the final result will be a family of curves similar to those of Fig. 2.

To support the spread curves of Fig. 2, Fig. 3 has been drawn to compare the spread curves of Fig. 2 with the average spread of a large number of batches, of different combinations of products, through Plantation system. Bearing in mind that the experience data plotted on Fig. 3 includes products of varying densities and viscosities, different, in some instances from the products used for Fig. 2, and that they include "induced" contamination, considerable support is given to the claim that Fig. 2 will indicate the order of expected contamination for any given line, if the proper interpolation between the curves is made for the two products in contact.

Some very interesting facts indicated by Fig. 3 are as follows:

1. The contamination spread at Birmingham is much greater than the curves of Fig. 2 indicate. This is explained by the fact that the initial contamination at the point of origin, caused by switching gate valves;

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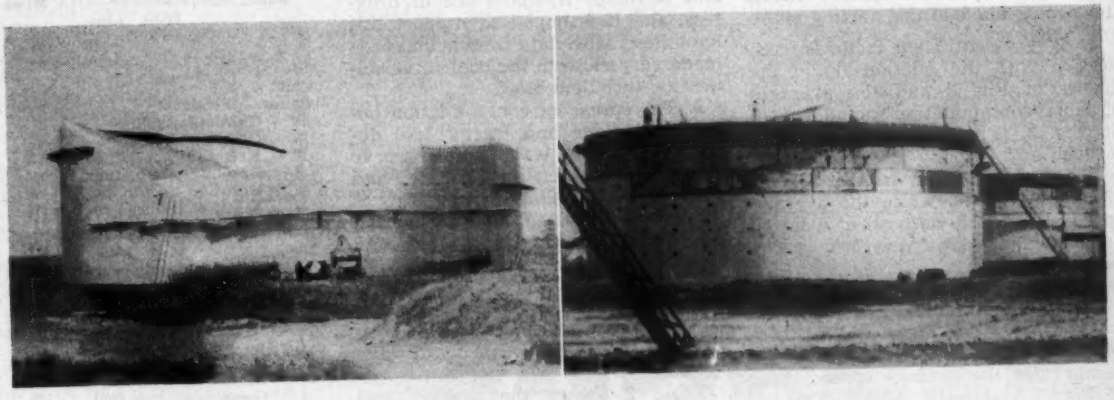

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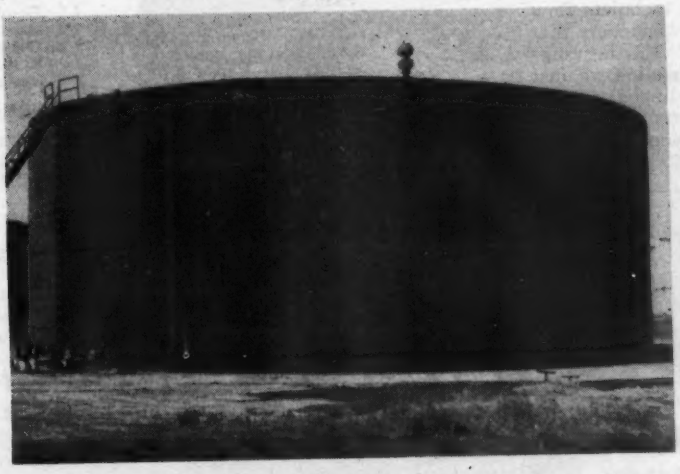

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flushing manifold barrels, meters, and strainers; hay tanks; and station piping, etc., is many times greater than the normal for the 12 miles of line, as indicated by Fig. 2. This establishes the fact that the curves of Fig. 2 will apply to short lines only if there is a **pure interface** between the two products at the starting point.

2. A very significant factor in connection with the relationship of the curves of Fig. 2 and the averages of actual contamination spread, shown on Fig. 3, is that the Fig. 2 curves derived at a velocity of approximately 7.5 ft. per second in the 12 and 10-in. main lines, while the average spreads of Fig. 3 were all at a lower velocity of approximately 5.45 ft. per second. Using an average viscosity between the gasoline and kerosine, the Reynolds number for the experiments from which Fig. 2 was derived was 490,000; whereas, the Reynolds number for the average spread data of Fig. 3 was only 354,000. This is offered in support of the contention that **the spread of contamination does not increase as the Reynolds number is decreased,** as long as turbulent flow is maintained. In fact, it appears that the opposite is true. As further support of this claim, gasoline against kerosine has been pumped in the 10-in. line at a velocity as low as 0.7 ft. per second, Reynolds number based on viscosity of kerosine, of 29,000, with no detectable abnormal spread between them. The same two products have been pumped through the 4-in. lines at velocity as low as 0.5 ft. per second, Reynolds number 20,000, with only normal spread. Experiments at even lower velocities and Reynolds numbers are in progress, and it is hoped to support this hypothesis with data from actual tests made very close to the critical velocities for turbulent flow.

3. The spread of contamination between kerosine and tractor fuel describes a fairly well defined curve between the gasoline-kerosine and the gasoline-gasoline curves. This is to be expected since the kerosine and tractor fuel are similar products and the spread between them should be less than the spread between gasoline and kerosine. The gasoline-tractor fuel spread, on the other hand, very closely follows the gasoline-kerosine spread.

Table 2 shows the gravity and kinematic viscosity of the products involved in the data of Fig. 3. This should be helpful in interpolating on Fig. 2 for any given products.

Table 3 lists the recorded data from which the points on Fig. 3 were derived.

TABLE 2

Product—	Specific gravity at 60°F.	Kinematic viscosity, centistokes at 100°F.	at 210°F.
Gasoline	.742	0.58	...
Tractor fuel	.802	1.07	0.56
Kerosine	.812	1.79	0.87
Diesel fuel	.846	3.20	1.29
Diesel fuel	.841	3.40	1.32

TABLE 3—(DATA FOR FIG. 3)

No. batches	Products	Avg. spread	Expected spread from Fig. 2
Baton Rouge-Bremen—431.6 Miles of 12-in. Line			
48	Gasoline-gasoline	335	*318
13	Gasoline-kerosine	660	*657
16	Kerosine-Diesel fuel	540	*657
3	Gasoline-tractor-fuel	645	*657
5	Kerosine-tractor fuel	490	...
5	Diesel fuel-diesel fuel	170	...
Bremen-Greensboro—356.8 Miles of 10-in. Line			
37	Gasoline-gasoline	235	*201
2	Gasoline-Kerosine	440	*413
4	Kerosine-diesel fuel	410	*413
Bremen-Knoxville—196.7 Miles of 8-in. Line			
21	Gasoline-gasoline	110	90
17	Gasoline-Kerosine	176	180
1	Gasoline-tractor fuel	176	180
13	Kerosine-diesel fuel	170	180
3	Kerosine-tractor fuel	145	...
Helena-Montgomery—72.3 Miles of 4-in. Line			
4	Gasoline-gasoline	17	12
7	Gasoline-kerosine	30	27
8	Gasoline-tractor fuel	28	27
4	Kerosine-diesel fuel	26	27
2	Kerosine-tractor fuel	20	...
Helena-Birmingham—12.4 Miles of 4-in. Line			
25	Gasoline-gasoline	20	6
7	Gasoline-kerosine	25	11
6	Kerosine-diesel fuel	25	11

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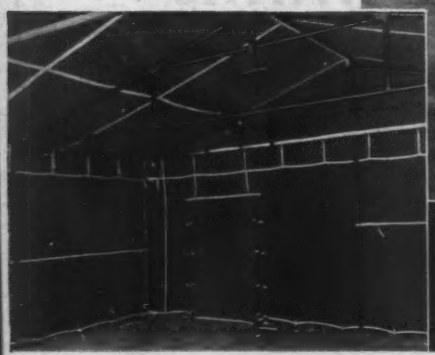

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Bremen-Macon—130 Miles of 4-in. Line

No. batches	Products	Avg. spread	Expected spread from Fig. 2
5	Gasoline-gasoline	20	19
3	Gasoline-Kerosine	36	38
3	Gasoline-tractor fuel ..	36	38
6	Kerosine-diesel fuel ...	38	38
1	Kerosine-tractor fuel ..	20	...

Bremen-Columbus—84.6 Miles of 4-in. Line

9	Gasoline-gasoline	14	16
4	Gasoline-kerosine	24	29
3	Gasoline-tractor fuel ..	22	29
4	Kerosine-diesel fuel ...	25	29

*Includes 6 per cent for induced contamination. (Only 6 per cent, instead of 11.6 per cent, as shown by Fig. 5, account this point is approximately midway of line.)

Factors Governing Spread of Contamination

As has been stated previously, the exact relationship among the factors involved in the spread of contamination between two products has not as yet been determined. The following are simply unproved opinions of the writer, concerning the factors which govern this spread; and, when presenting them, we are like the minister who shouted the loudest when his arguments were weakest. In our opinion the factors which affect the spread of contamination are:

1. Differential velocity over the cross-sectional area of the pipe. Due to "drag" along the inner surface of the pipe, the fluid at the center of the pipe flows faster than near the pipe walls. It seems logical that, as the friction along the pipe walls increases, the drag would increase, and the spread of contamination would increase. In turbulent flow, the average velocity through the cross-section of the pipe is thought to be as high as 0.82 of the maximum velocity; whereas, in streamline flow, the average velocity is only 0.5 of the maximum velocity. This should account for the fact that spread of contamination is greater in streamline flow than in turbulent flow. These relations give no indication of the amount of spread—they are used here only qualitatively.

2. Differential density of the fluids in contact—a difference in density between two products is thought to add a gravitational force which apparently acts to accelerate the spread of contamination, the heavier product tending to underrun the lighter product. This influence lessens as the mixture reaches a point where the change from the density of one product to that of the other is very gradual. This hypothesis is offered in explanation of the fact that the **rate of spread** of contamination diminishes as the products move through the line. To illustrate this concept, Fig. 4 shows the $Y = 1.93\ X^{0.839}$ curve of Fig. 2 drawn on coordinate paper for the main line of Plantation's system.

The points indicated by O on Fig. 4 were plotted from an actual batch. It is noted that these points, on the 12-in. line, starting with an initial contamination at 91 bbl. out of Baton Rouge, find and follow the theoretical curve very closely, with a slight increase at Bremen due to induced contamination. By comparing the spread of curve $Y = 1.93\ X^{0.839}$ between Bremen and Greensboro, (155 bbl.), with the spread on the actual test curve between the same points, but starting at Bremen, (430 bbl.), it can be seen that the contamination between Bremen and Greensboro would be increased to 277 per cent of normal by cutting the batch out at Bremen and repumping it to Greensboro. This illustrates a statement already made that heart-cut deliveries should be made from batches of fuels, or other products between which the contamination is a problem, and the contamination should be allowed to go undisturbed to the final terminal for the products.

3. Viscosity.—The part played by viscosity in the spread of contamination between two products is not fully understood. The writer believes that viscosity is a **retarding** influence to the spread of contamination. This seems logical because high viscosity would tend to resist the establish-

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ment of a differential velocity, through a cross-section of the pipe. It would seem to counteract, to some extent, the frictional drag along the pipe walls. It is a fairly well established fact that the friction along the pipe walls, in turbulent flow, **varies only slightly with increase of viscosity.** At the same time, a high viscosity, of both products, would retard differential velocities. We do not, at this time, have conclusive proof of this hypothesis. We might refer, however, to the point, on Fig. 3, showing the spread between two types of diesel fuel. The spread between these two products of relatively the same specific gravity is much less than the spread between two gasolines of the same relative specific gravity. The only apparent explanation for this is the high viscosity of the diesel fuels, as compared to the gasolines.

Contamination Spread in Shut-Down Lines

It has been the general opinion, in the products-pipe-line industry, that to shut down with kerosine and gasoline, or other relatively dissimilar products, in contact with each other causes prohibitive spread of contamination. This concept, and the 2½ ft. per second minimum velocity rule, imposed severe restrictions on operations of Plantation's line. With 17 takeoff points, short batches, and multiple products, it was found to be physically impossible to keep products moving at a velocity greater than 2½ ft. per second, when fuels were in the line, and make the required deliveries. It was, therefore, necessary to either disprove these hypotheses or to work out some arrangement in which only long batches with limited intermediate takeoffs were put behind fuels in the line.

With this in mind, Plantation made tests to determine the influence on the spread of contamination of falling below a velocity of 2½ ft. per second and of shutting down the line with fuels in it.

It has been shown, earlier in this article, that no excess spread was noticed with velocities as low as ½ ft. per second, but with Reynolds numbers not lower than 20,000. To determine the effect of shutting down with fuel against gasoline, a test batch of kerosine was pumped to the 4-in. Bremen-Macon lateral line. The line was shut down under a pressure of 225 psi. for a period of 57 hours. After the shutdown period the line was started up and the batch arrived at Macon with only normal contamination.

Fig. 6 shows the topography of the line where the test batch lay during the shutdown period. From this chart, it is possible to draw the conclusions that:

1. The normal topography of the land has little effect on spread of contamination, in shutdown lines, at least, within reasonable limits. It will be noted that from Point A to Point B there is a difference in elevation of 160 ft. over a distance of approximately 1,600 ft. This amounts to a 10 per cent grade; and is sufficient to indicate the lack of effect of elevation on the spread of contamination.

Change Very Gradual

To explain this lack of effect, we again offer the hypothesis that the change from one product to the other is so gradual that very little force, because of gravitational pull, is present after the change from the density of one product to that of the other becomes very gradual.

2. The amount of pressure, as long as the line remains tight, has negligible effect on the spread of contamination in shutdown lines. This is offered without further proof, as it is apparent that probably the only effect a pressure pack could have would be a tendency to equalize the density of the two products, because of differential compressibility, thereby reducing the gravitational force between them. Since, in the foregoing, the gravitational force is shown to be negligible, no further argument should be needed; however, if the compressibility factors of 0.6 per cent per 1,000 psi. for kerosine, and 0.8 per cent per 1,000 psi. for gasoline,

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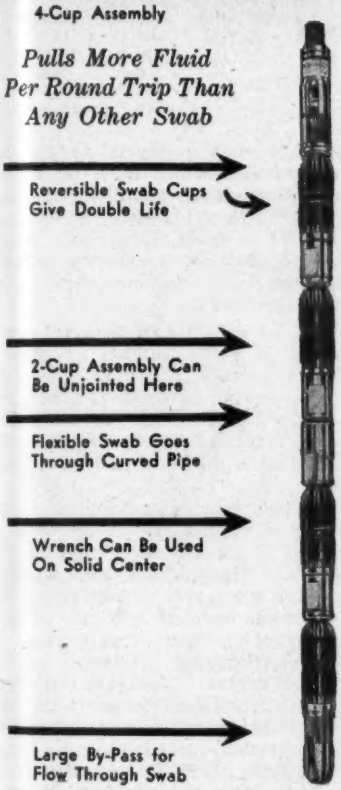
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are used it can be seen how insignificant is the effect of 225 psi. pressure on the differential density between the two products. Since the above experiment, Plantation has shut its laterals down over week ends, regularly, with fuels in them; and no prohibitive spread of contamination has resulted therefrom.

Flash Point of Fuels

The data of Figs. 2 and 3 consider only the physical mixing of two products within the limits detectable by hydrometer determinations of the A.P.I. gravity.

There is a further contamination between such products as gasoline and kerosine which must be considered. Very small quantities of gasoline will have a big effect on the flash point of kerosine. Roughly, 0.25 per cent of gasoline in kerosine will reduce the flash of the kerosine as much as 25° or 30° F.

Fig. 5 shows the relationship of the spread of contamination by gravity to the spread of contamination by "flash point," between gasoline and kerosine. This chart was compiled from a typical batch. From it, the following significant facts are indicated:

1. The spread of contamination, determined by gravity, is 860 bbl. as against a theoretical spread of 770 bbl. from Fig. 2. This is approximately 11.5 per cent greater than the theoretical spread, because of disposing of drainage from sumps at stations, flushing hay tanks, etc., or induced contamination. On lines having no intermediate stations, the spread should follow more closely to the theoretical spread shown by Fig. 2.

2. Taking 115° F. as satisfactory flash, it was not until 1,180 bbl. after the first change, from gasoline to kerosine, that good flash was reached. It was, therefore, 1,180/770 or 153 per cent of the theoretical spread, after the first change, before good flash kerosine was reached.

3. The product between 860 bbl., where good kerosine gravity was reached, and 1,180 bbl., where the flash became 115° F., was kerosine with enough gasoline in it to lower the flash, but not sufficient to show up on the hydrometer. Although the "drift" of low flash material from the head end of the batch will vary with each pipe line, according to its complexity of operations, Fig. 5 indicates the necessity to determine the extent of such drift before switching the stream to kerosine storage, on the head end of kerosine batches in contact with gasoline.

4. It will be noted that the kerosine ultimately reaches a flash of 124° F. it is considered good practice to ship in pipe lines kerosine

TABLE 1—CAPACITY OF PIPE IN BARRELS OF 42 GAL. AT 60° F. PER FOOT OF LINE

$I.D.^2 \times 0.0009714263 = \text{Cap. per ft.}$

Size—	4-in.	6-in.	8-in.	10-in.	12-in.	14-in.	16-in.
Wt. Ft. P. E.	10.790	18.974	28.554	40.483	49.562	45.68	62.579
Wall thickness	.237	.280	.322	.365	.375 3/8	.3125 5/16	.375 3/8
I.D.	4.026	6.065	7.981	10.02	12.00	13.375	15.25
$I.D.^2$	16.2087	36.7842	63.6964	100.40	144.00	178.8906	232.5625
Length in feet:							
1	.0157456	.0357331	.0618764	.0975312	.1398854	.1737790	.2259173
2	.0314911	.0714663	.1237527	.1950624	.2797708	.3475581	.4518347
3	.0472367	.1071994	.1856291	.2925936	.4196562	.5213371	.6777520
4	.0629822	.1429326	.2475054	.3901248	.5595415	.6951161	.9036693
5	.0787278	.1786657	.3093818	.4876560	.6994269	.8688952	1.1295866
6	.0944733	.2143988	.3712581	.5851872	.8393123	1.0426742	1.3555040
7	.1102189	.2501320	.4331345	.6827184	.9791977	1.2164532	1.5814213
8	.1259645	.2858651	.4950109	.7802496	1.1190831	1.3902323	1.8073386
9	.1417100	.3215983	.5568872	.8777808	1.2589685	1.5640113	2.0332560

Example: To find capacity of 6-in. line, 18.974 lb. per ft., 0.280 wall thickness, 4,378 ft. long.

Computation:

4,000 ft. =	142.93260
300 ft. =	10.71994
70 ft. =	2.50132
8 ft. =	0.28587
4,378 ft. =	156.43973

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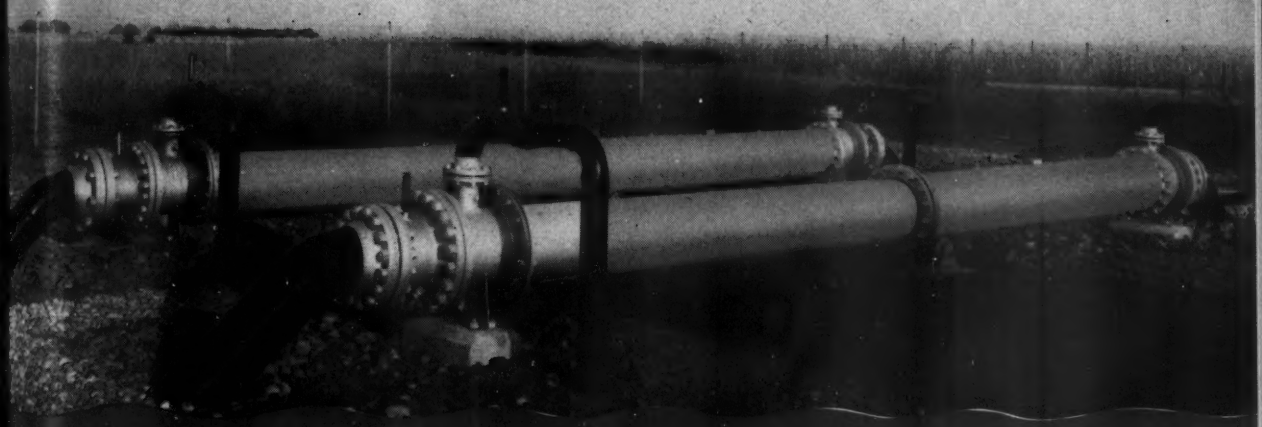

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Application of Contamination Spread Data to Design of New Line

In the foregoing, a method for estimating the amount of contamination to be expected in a given line was offered. It will now be illustrated how this information can be used in the design of a new line, from the standpoint of contamination control.

Assume the following:

1. Two hundred miles of line from a point A to a distribution center B.

2. Daily throughput of 15,000 bbl. per day divided:

80 per cent motor fuels = 12,000 bbl. per day.

15 per cent kerosine = 2,250 bbl. per day.

5 per cent diesel fuel = 750 bbl. per day.

In considering the size of pipe to be laid, the sizes of tanks at terminals, etc., the contamination data can be used as follows:

1. By consulting Fig. 2, it is seen that the spread between gasoline and kerosine in an 8-in. line 200 miles long is 183 bbl. (Fig. 5 indicates that the head end will have an additional 11.5 per cent of spread between the products, and a quantity of low-flash kerosine, on lines having intermediate stations and complex operations; however, for a simple, one-station line, as in this example, these factors can be ignored.)

Ignoring induced contamination, there will be a total (both ends) of $2 \times 183 = 366$ bbl. of contamination between gasoline and kerosine of which approximately 50 per cent or 183 bbl. is kerosine to be disposed of into gasoline. Since diesel fuel-kerosine contamination spread follows fairly close to the kerosine-gasoline curve, there will likewise be a total of 183 bbl. of kerosine to dispose of into diesel fuel.

By experiment, it can be determined what percentage of kerosine can be blended into gasoline without degrading the gasoline and what percentage of kerosine can be blended into the diesel fuel. For this example, assume 0.5 per cent of kerosine in gasoline, and 3.0 per cent of kerosine in diesel fuel.

Considering disposal of the contamination at the end of the line:

183 = 0.5 per cent of 36,600 bbl.

183 = 3.0 per cent of 6,100 bbl.

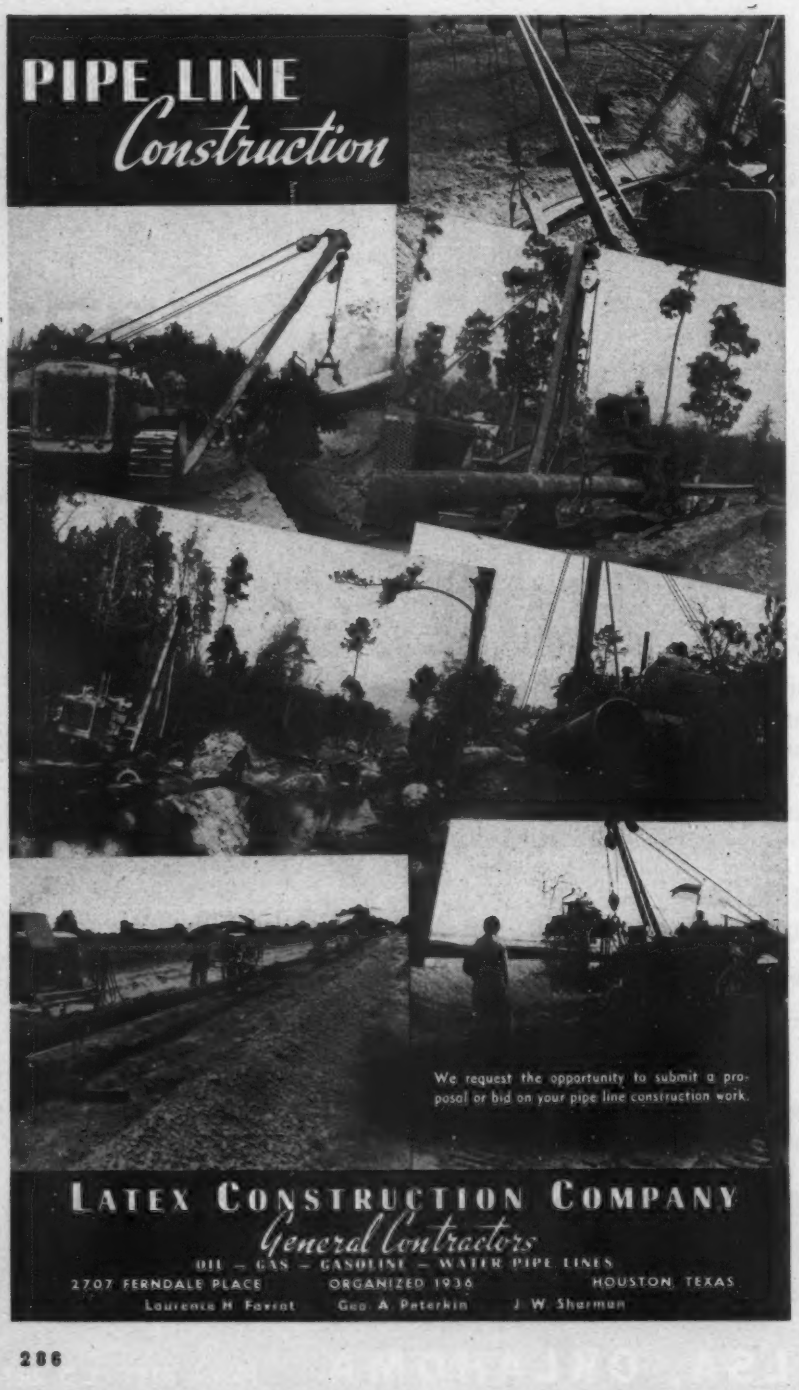
Consulting the daily throughput figures, this indicates there would be enough gasoline received every 36,600/12,000 = 3.05 days to dispose of the gasoline-kerosine contamination; and that the amount of diesel fuel required to work off the kerosine-diesel fuel contamination, 6,100 bbl., would be 6,100/750 = 8+ day supply.

On this basis, since kerosine and diesel fuel would invariably be handled together, the two products could be scheduled every 10 days (cycles are usually multiples of 5, for convenience) and tank sizes at terminals for kerosine and diesel fuel could be designed to hold a 10-day supply plus the appropriate margin for inventory fluctuation.

The usual formula for terminal tankage is 210 per cent of the maximum requirements for the accepted cycle. Disregarding the seasonal fluctuations for the sake of simplicity, the required terminal tankage would be $2.10 \times 10 \times 750$ or 15,750 bbl. for diesel fuel and $2.10 \times 2,250$ or 47,250 bbl. for kerosine.

If the line has several points where deliveries are made, heart-cut deliveries will probably be made at intermediate terminals; and the contamination control data will be applied to the last terminal on the line. In such instance the daily requirements at the final terminal should be used in determining the cycle for each product.

In the above example, suppose that, to handle the desired 15,000 bbl. per day, either a 10-in. line was required or an intermediate pumping station on the 8-in. line. If a 10-in. line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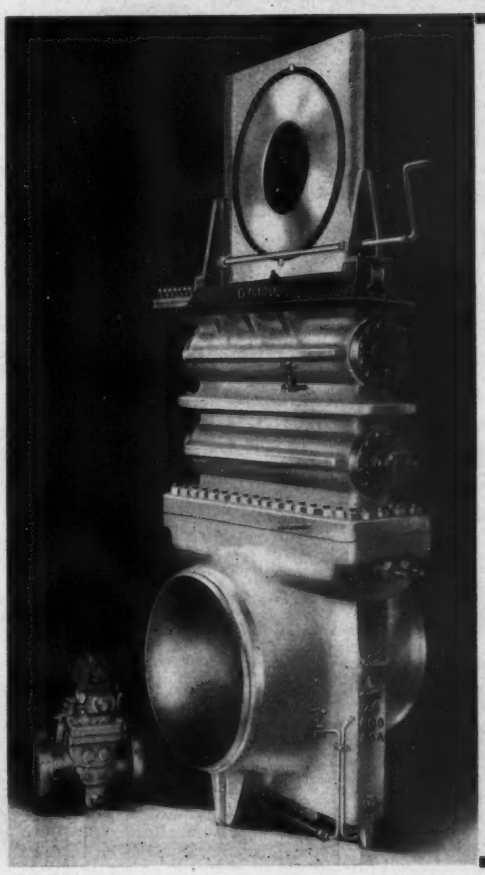

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were laid, again referring to Fig. 2, there would be 286 bbl., instead of 183, of kerosine to go into gasoline, and a like quantity of kerosine to go into diesel fuel. In this case:

286 = 0.5 per cent of 57,500 bbl. = 4.8 days supply

286 = 3 per cent of 9,533 bbl. = 12.7 days supply

Laying the 10-in. line would require a 15-day cycle for kerosine and diesel fuel, and the storage requirements would become:

$2.10 \times 15 \times 750 = 23,625$ for diesel fuel and $2.10 \times 15 \times 2,250 = 70,875$ for kerosine.

In this example, it would be necessary to decide whether to build the 10-in. line, with the attendant increased cost of construction plus an additional 31,500 bbl. of storage at the terminal, or the 8-in. line with an intermediate pumping station.

The means of estimating contamination tank sizes by using the contamination spread data is obvious.

Minimum Batch for Contamination Control

There has been some tendency in the pipe-line industry to express the contamination between two products as a "percentage contamination." It is thought that this term originated on crude lines operating in streamline flow, with float tanks in the system, etc., where there was some degree of contamination throughout a batch of special product run through the line. Even under these conditions, percentage contamination is meaningless, since it depends upon the relative sizes of the batches and the extent of the contamination spread.

As an illustration of the foregoing, consider the 200-mile, 8-in. pipe line in the preceding example. The spread between kerosine and gasoline is 183 bbl. on each end: total 366 bbl. of contamination. Of this quantity, 183 bbl. is kerosine which will probably be blended into gasoline. Suppose A Co., who has shipped the kerosine and must, therefore, take the contamination, has a batch of 5,000 bbl. of gasoline on each end of the kerosine batch. If A Co. should cut the contamination directly to the gasoline, the percentage contamination would be $183/10,000 = 1.83$ per cent contamination of gasoline by kerosine. On the other hand, if A Co. had 25,000 bbl. on each side of the kerosine batch, the percentage contamination would be $183/50,000 = 0.37$ per cent.

Although the term percentage contamination, itself, has no significance, insofar as expressing the amount of contamination is concerned; it certainly is a factor to be dealt with in setting up traffic rules for minimum batches.

By minimum batch is meant the minimum quantity of a given product which will be pumped by the pipe line in one batch for one shipper. This of course, does not include buffer batches, which are used as an operating necessity, in contamination control.

Each pipe line must designate the minimum for batches through its system. It is not possible to set up a formula which will apply to all lines, as a different set of conditions will exist in practically every pipe-line system.

In arriving at the logical minimum batch, the chief factors for consideration are:

1. Contamination between products.
2. Effect of small batches on operations.
3. Effect of small batches on investment.

Concerning (1), the disposability of contamination between products is probably the major consideration. For example, the spread of contamination between kerosine and diesel fuel, through Plantation's main line, is approximately 800 bbl. on either end. Of the 1,600 bbl. total contamination, roughly 800 bbl. is kerosine to go into the diesel fuel. Not more than 3 per cent of kerosine can be put into diesel fuel. It is essential that a large enough batch of diesel fuel be run to absorb the contamination; and, since 800 bbl. is 3 per cent of 26,666, it is indicated that 25,000 bbl., in round figures, is

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the proper minimum batch size for diesel fuel through Plantation's system.

While 25,000 bbl. seems to be the ideal minimum batch size for Plantation's system, from the standpoint of contamination control, it need not be considered applicable to all pipe lines. Again, consider the 200-mile, 8-in. line of previous illustrations. The 183 bbl. of kerosine to be put into diesel fuel would require 183/0.03 = 6,100 bbl. of diesel fuel. On this basis, the line might well establish a minimum batch of 7,500 or 10,000 bbl. for diesel fuel. Examining the other products to see how they are effected, it is seen that the 183 bbl. of kerosine to go into gasoline, on the basis of 0.5 per cent will require 183/0.005 = 36,500 bbl. of gasoline. As the gasoline requirements were 12,000 bbl. per day, this would be only a 3-day requirement. If fuels were pumped every 10 days, there would be ample gasoline pumped within the period to absorb the kerosine contamination. On this basis, the 200-mile, 8-in. line might find a 7,500 bbl. minimum batch entirely satisfactory. Of course, the other products to be handled should be analyzed in the same manner, and the most restrictive condition taken as the index for the minimum batch.

Concerning (2), effect on operations of small quantities, if the product were of the same general specifications as other products being currently handled, no disturbance to operations should occur. For example, if a brand of gasoline similar in density to other gasolines being handled were offered for shipment, it would make no difference from the standpoint of line balance, whether the batch were 5,000 or 100,000 bbl. If, however, the product offered for shipment were a heavy, viscous product, which would pump at a rate much slower than the gasoline rate, it would upset the balance of the line. Units ahead of and behind the batch of heavy products would have to throttle pressure to avoid running away from, and over, the station pumping the heavy product. This would result in a waste of horsepower and a reduction in throughput to the line. Unless some restrictions were placed on such batches, the line might lose as much as 20 per cent of its throughput by having small batches of heavy products scattered haphazardly throughout its schedule. The solution, of course, is to establish regular cycles for the handling of heavy products and to set a minimum batch restriction which would best fit the line in question.

In regard to (3), effect of small batches on investment for facilities to handle a product, again the problem becomes distinctive to the company involved. It is the present practice for a products pipe line to supply tankage at the point of origin, into which to receive, from the shipper, the products to be pumped through the pipe line.

To draw a comparison, as illustration of this point, Planation's point of origin, Baton Rouge, is very flat country, only a few feet above sea level. Some of the tanks are of necessity remote from the station, and the pumping rates to the line are high. This makes it necessary to install a booster pump at each tank. The approximate cost of the booster pump, tank dikes, and lines is approximately $10,000 per tank. With this investment for appurtenances, it would be prohibitive to build a large number of small tanks, and the 25,000-bbl. minimum is needed to insure a proper ratio between investment and expected throughput. In the instance of the 200-mile, 8-in. line, however, the rate would be low enough that one booster pump, located centrally in the tank farm, might serve all the tanks. In this event, the initial investment would be so much lower that the 7,500-bbl. minimum batch might be in order.

Acknowledgments

W. J. Curry of Shell Products Pipe Line Co. as mentioned; F. E. Warterfield, Jr., who made helpful suggestions; John W. Flahie, Tom L. Martin, and others, who helped gather and interpret the data involved; and Plantation management who never lost interest and who gave helpful encouragement.

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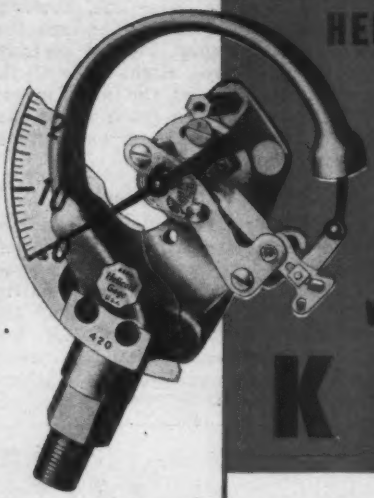

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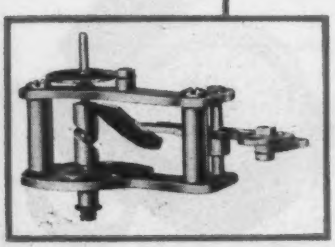

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An Experience With The "Megger"

(Continued from page 192)

of the megger by means of wires with clips on them to facilitate the attaching and detaching operation. The current goes into the outside pegs and returns through the ground to the inside pegs. The actual resistance in ohm-cm may be obtained by multiplying the average resistance read by a constant which varies according to the depth to which the average resistance is obtained.

Several things were done in preparation for the megger survey. First, the average depth from the ground surface to the bottom of the pipe was determined from a profile map as being 4 ft. Second, it was decided to take readings at intervals of 20 ft. from setup to setup. Third, the iron pegs were tied together 4 ft. apart by means of strong cotton cord. Two sets of pegs were used to expedite the operation. Fourth, the pipe line was staked out by using an electronic pipe locator so that the contact pegs could be kept far enough away from the pipe to prevent it from being included in the average resistance. Fifth, it was decided to use a three-man crew with one man running the instrument and recording results, one man driving pegs, and the third man measuring distances and connecting wires to the pegs. It was found that the easiest way to measure was by using a 4-ft. lath The distance between the last peg of one setup and the first peg of the next setup was 8 ft. or two lath lengths making the distance 20 ft. between setups. To obtain a correct reading with the megger it is necessary that the instrument be approximately level. We, therefore, mounted two bubble levels on the megger at right angles, and had three small wedges made to aid in leveling on sloping ground.

The survey was started at the northerly end of the section to be reconditioned at the base of the hills in sandy soil. The first 2,300 ft. consisted of outcroppings of various sandstones, conglomerates, and decomposed shales. The top soil ranged from sandy to heavy clay deposits with the high-resistant sand more in the depressions and the low-resistant clay on or near the humps. (Fig. 1).

At the top of a hill at station 23 + 00, the soil quite abruptly changed to a reddish-brown sand and conglomerate. This extended for 1,300 ft. and was found to be consistently higher in electrical resistance than the previous 2,300 ft. At the top of another hill the soil abruptly changed back to the original type and continued giving the same results as those in the first 2,300 ft. for another

2,100 ft. At this point the pipe line left the hills to traverse a flat sandy glen the remainder of the distance to the state-highway crossing. This last 600 ft. was found to be very high resistant, comparatively speaking, which seemed to be typical of these sandy soils.

Test holes were dug to check the condition of the pipe at most of the spots that showed the lowest electrical resistance. At station 3 + 40 we were quite encouraged when we dug up a corrosion leak that had not yet shown on the surface. At this particular place the pipe was just passing from a clay soil to a sandy soil and apparently the corrosion was caused by galvanic action due to dissimilar soils. Pitting was not found in all of the test holes for several reasons. In some cases the pipe was shallow and did not come in contact with the low-resistant soil underlying the top soil which influenced the megger reading. In other cases the test hole would miss the bad pipe by a few feet. This was quite apparent when the pipe was uncovered and raised above the ditch for cleaning and treating. These test-hole locations and other low-resistant spots not investigated were marked by laths with the megger reading and stationing inscribed on them for identification. They were offset from the pipe line a sufficient distance to prevent their being disturbed during the reconditioning operations.

From our past experience with the megger, we have never found any bad pipe where the average electrical resistance of the surrounding soil was greater than 4 ohms. We, therefore, took this as a criterion and after the results were plotted, governed our decision to recondition or not to recondition accordingly. This is shown quite clearly in Fig. 1. The stretch from station 19 + 00 to 23 + 00 was on a steep hillside where the pipe was barely covered with loose dirt and where it appeared to be in excellent condition. We decided, therefore, to end the reconditioning at the base of this hill.

To check the results of our survey, a thorough inspection of the pipe was made immediately following the pipe-cleaning machine and before the application of the primer. The depth of the deepest pits was measured and recorded. These results were plotted on an inverted scale (Fig. 1) to demonstrate the correlation between the pit depths and the megger readings. It will be seen that in most cases the deepest pitting occurred in the low-resistant areas.

From these results it was decided to recondition only 4,000 ft. of the 6,300 ft., thereby saving the cost of reconditioning 2,300 ft. in some of the roughest of the country. To this date we have had no trouble in the section of pipe left bare and we are not anticipating any visit from corrosion in the near future.

Review of 1947 Construction

(Continued from page 185)

Drumright to Manhattan and 18-in. from Manhattan to Whiting. This big-inch line built in loops in the 1946-47 period will be put in operation as a unit at the end of this year. This big-inch program enables the company to shut down four main-line pump stations. At other points on the system 12 new stations have been put in operation.

Larger crude-oil shipments will be handled from West Texas by the 70-mile Wheeler-Wasson, West Texas extension and by 265-mile 16-in. looping of the Slaughter, Tex.-Drumright, Okla., 16-in. line in 1948.

Next year Stanolind's Rock Mountain facilities will be increased by the Lysite-Casper 70-mile 12-in. looping, by a Wamsutter-Casper 130-mile 8-in. line, and by Casper-Freeman, Mo., 199-mile 12-in. loops.

Big Steps by Gas Companies

The 908-mile gas-transmission projects being planned by El Paso Natural Gas Co. to meet rising demands for gas in California include a 470-mile 26-in. line from San Juan County in

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northwest New Mexico to connections with Pacific Gas & Electric Co. at Needles, Calif., and also the 438-mile 26-in. looping of El Paso Natural's 740-mile 26-in. line now under construction from the Permian basin to Blythe, Calif. This line is to be completed to Blythe late this year to connect with the Southern California Gas Co. and Southern Counties Gas Co.'s 214-mile 30-in. Blythe-Los Angeles line which is being finished this month.

El Paso Natural's plans for the San Juan Basin-Needles system suggest that Pacific Gas & Electric Co. will undertake new pipe-line construction for handling gas to be received from El Paso Natural early in 1952.

Negotiations have been reported for a 1,000-mile 20-in. line from Midland, Tex., to Wilmington, Calif., to be built by a group headed by Shell interests. This proposal is said to be still in the discussion stage. Allocations of crude oil from South America as well as from West Texas are important factors to be reckoned with in the problems, involving this project, which are global in their scope.

Sunray Oil Co.'s 93-mile 6-in. products line is being laid as a plant facility between the Allen and Beckett, Okla., refineries.

For more than a year Texas Pipe Line Co. has been preparing to lay a 60-mile 16-in. West Columbia-South Houston crude-oil line as well as an 80-mile 20-in. South Houston-Port Neches and Port Arthur crude-oil line.

Houston-Bryan Line

Sinclair Refining Co. aims to procure sufficient pipe this fall to justify the letting of contracts for starting construction of a 10-in. line from Houston, via Bryan, Tex., to the Dallas-Fort Worth area. At Bryan this line will connect with the system now being laid by Sinclair from Corpus Christi, Tex., to serve Luling, San Antonio, and Austin.

Later the Houston-Dallas and Fort Worth line will be extended via Kansas City and St. Louis to Chicago to connect with previously laid lines to form a connecting link between Houston and Corpus Christi on the Gulf Coast and the Sinclair refinery at Marcus Hook, Pa., on the East Coast.

Hearne, Tex., in the Bryan area, is also becoming a notable products pipe-line terminal point. Magnolia Pipe Line Co.'s 178-mile 12-in. products line from Beaumont to Hearne feeds into Texas Pipe Line Co.'s Hearne-to-Dallas and Fort Worth 172-mile 10-in. line. Last year the first of the products lines extending northward from the Gulf Coast to the Dallas-Fort Worth area was built by Humble Pipe Line Co. with a station and terminal located near the company's Hearne pump station facilities for its crude oil and butane lines.

In the eastern states, Socony-Vacuum Oil Co., Inc., put in operation, the beginning of the year, the Paulsboro, N. J.,-Midland, Pa., products line commenced in 1941 and interrupted by the war. Socony-Vacuum will lay a 127-mile products line from Portland to Bangor, Me.

Difficulty in getting pipe has made it necessary to curtail certain projects. Consequently, Phillips Petroleum Co.'s Borger, Tex.,-Denver 385-mile 6-in. products line is being built this year only to La Junta, Colo.

Cities Service Co.'s 405-mile 26-in. gas line from Hugoton field to Kansas City is to be built in two sections totaling approximately 240 miles in 1948. The Hutchison-Ottawa gap to be built in 1949 will complete the project.

Michigan-Wisconsin Pipe Line Co.'s 1,069-mile 22-26-in. line from Hugoton field to Michigan is endeavoring to procure enough pipe to start construction January 1, 1948, the date specified in its permit from the Federal Power Commission.

Large gas projects announced earlier this year include looping programs of Tennessee Gas Transmission Co., Natural Gas Pipeline Co. of America, Panhandle Eastern Pipe Line Co., and Northern Natural Gas Co. as well as a new system to be built by Atlantic Gulf Gas Co., a subsidiary of United Gas Corp., for transmitting gas to points in Alabama, Florida, Georgia, and South Carolina.

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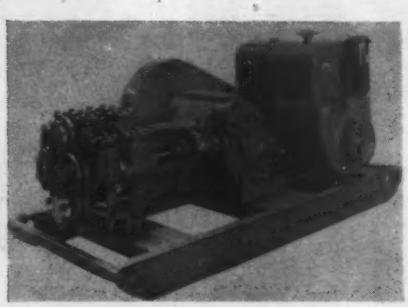

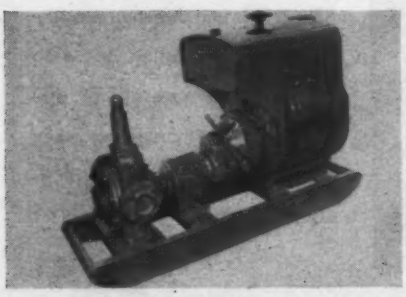

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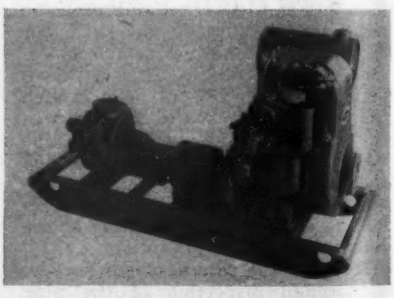

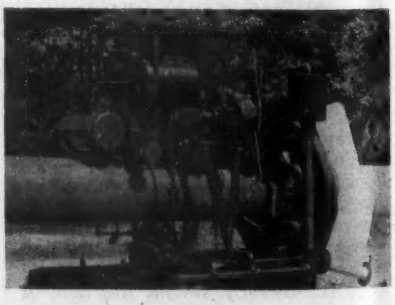

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True RESISTIVITY DETERMINATION from the Electric Log—

Its Application to Log Analysis

by H. G. Doll, J. C. Legrand†, and E. F. Stratton‡*

THE electric log gives two electrical parameters of the geological formations traversed by the bore hole, namely, the spontaneous potential[1], which usually is designated as SP, and the resistivity[2]. The resistivity is measured while applying a current which is caused to flow through the formations by means of an electrode or electrodes positioned in the drill hole. This current gives rise to differences of potential betwen electrodes which are located at known distances from the current electrodes. These differences of potential are a function of the resistivity of the medium in the neighborhood of electrodes, for a given current and for a given electrode arrangement. The resistivity value is computed according to Ohm's law.

It is customary to record several resistivity curves which are known as normal curve, lateral or inverse curve, etc. For the sake of simplicity, only the normal curves will be considered in the following discussion. It should be remembered, however, that most of the statements will apply equally well to lateral curves, taking into account the differences in the geometry of the electrode devices. Particularly, the determination of true resistivity can be made in a similar way from measurements taken either with normal or with lateral electrode arrangements.

Several electrode spacings for the normal devices are usually run in the bore hole to vary the effective depth of investigation. When examining an electric log, it will be noticed that the resistivity values recorded at a given depth in a well may be different from one curve to the next. This is because the measurement does not deal with a single uniform and infinite medium, but rather with a series of zones, each of finite dimensions and each having its own resistivity.

*Director of research, †technical department, and ‡exploitation department, Schlumberger Well Surveying Corp., Houston. A paper presented at the 1947 spring meeting of the Pacific Coast district, Division of Production, American Petroleum Institute, Los Angeles.

Electrode Device

As indicated in Fig. 1, the electrode device, which is often called the "sonde," is placed in the drill hole. Usually the drill hole is filled with a water-base mud, which exhibits a resistivity varying between 0.05 ohm meter for salty mud and 20 ohm meters for very fresh water mud; frequently this mud resistivity is comprised between 0.5 and 3 ohm meters. The mud column is surrounded by the geological formations. If the electrode device is opposite an impervious stratum, as far as

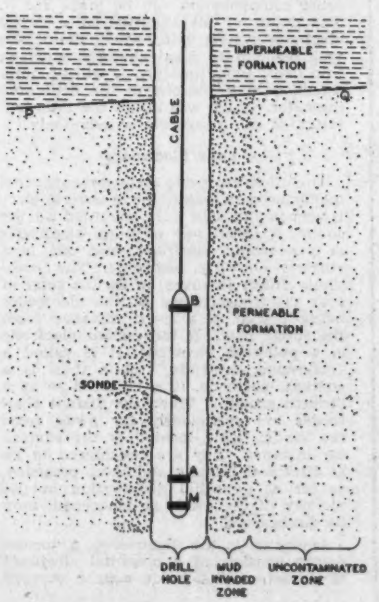


Fig. 1

resistivity measurement is concerned, this corresponds to the case of two media in contact: the mud column and the formation. On the other hand, if the sonde is opposite a permeable bed, there is an intermediate zone due to invasion, which is contaminated with mud filtrate, beyond which is located the formation in its original undisturbed state. This is a three media case.

It is quite apparent that the resistivity of each of the media located in the vicinity of the sonde will play a part in the resistivity measurement. When a small electrode spacing is used, the mud in the hole may have a dominant effect, in view of the small depth of investigation of the electrode device. If the spacing is increased, the effect of the volume of material in the immediate vicinity of the device is minimized, and, for large spacings, the resistivity of the undisturbed formation will become dominant.

It should also be kept in mind that the strata encountered in a drill hole have a finite thickness. Accordingly, in the vicinity of a boundary such as PQ of Fig. 1, the device will be influenced not only by the mud and the lower stratum but also by the upper bed. This is the reason resistivity measurements of thin strata are difficult to obtain with accuracy. To avoid confusion, this paper will not deal with thin beds, but only formations whose thickness is sufficiently large will be considered, so that the effect of the adjacent strata can be ignored.

The oil producers are interested in possessing data which will help in determining the oil productivity of a reservoir. As will be seen later, the resistivity of the uncontaminated formation is very important in this respect. The resistivity of the uncontaminated formation is called the true resistivity and designated by Rt.

In contrast, the resistivity measured in the drill hole, which is influenced by other factors besides Rt, is designated as apparent resistivity or Ra. While Rt has a definite value for a given formation, Ra will vary according to the electrode spacings. Furthermore, for a given sonde, the apparent resistivity differs more from the true resistivity when the diameter of the hole is larger and the ratio of the resistivity of the surrounding formation to the mud resistivity is greater. Also, in the case where mud invasion is present, the apparent resistivity will differ more from the true resistivity when the mud infiltration is greater and the difference between the resistivity of the mud and the resistivity of the connate fluid is greater.

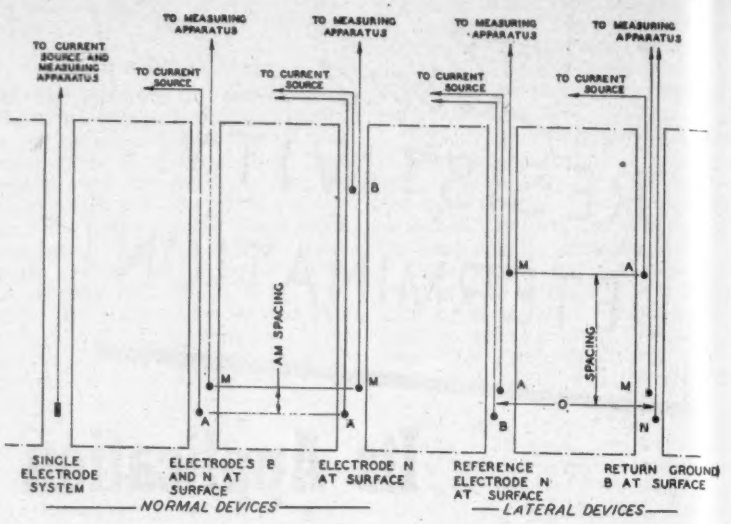
The above remarks show that a resistivity measurement made with electrodes placed in the bore hole will yield an apparent resistivity which may differ from the true resistivity of the undisturbed formation. They also indicate that, to get an apparent resistivity value close to the true resistivity value, large spacings are desirable. Unfortunately, it is not always possible to use spacings large enough to be fully satisfactory, because of the bed thickness. If the electrodes of the normal device are too close to a boundary of the formation under investigation, the adjacent stratum will influence the measurement, hence the answer will be inaccurate.

It can be shown that for proper determination of resistivity in practical cases, the formation should have a thickness at least four times the spacing AM for a normal device, A and M being the two "active" electrodes of the device. If this condition is fulfilled, in most cases the apparent resistivity will be sufficiently accurate for quantitative analysis from the log.

For correlation purposes, it is also desirable to use small electrode spacings as they will give many details on the log. A smaller spacing will permit a better definition of the boundaries of the different strata, thus giving more accurate information on the thickness of oil reservoirs. Accordingly, it is customary in field operations to record several resistivity curves with different electrode spacings. This present technique is quite helpful in determining the true resistivity Rt.

Resistivity in Vicinity of Bore Hole

The conditions in a bore hole are represented schematically in Fig. 2, following the paper by Martin, Murray, and Gillingham[1]. The general arrangement can be characterized, first, by a medium of cylindrical shape representing the bore hole filled with a homogeneous mud of resistivity Rm. A second medium is made up of the zone invaded by the mud filtrate, in the case of a per-



ELECTRODE ARRANGEMENTS—Here are shown the single electrode system, the two normal devices, and the two lateral hookups for greater depth of investigation. Discussion by the author of each of these electrical logging systems is given below:

Several types of electrode devices have been used in electrical logging. Usually, two different types of electrode arrangements are run in the same hole, to obtain a picture as complete as possible of the resistivity of the formation. For instance, the normal device will give a good definition of beds, except for very thin strata. The lateral device, on the other hand, will show the thin formations very well; it will also be helpful in case of very great mud invasion.

The simplest device is (see diagrams) a single electrode arrangement.[7] The resistance of the electrode located in the hole is measured. It is affected primarily by the material immediately surrounding the electrode. Accordingly, the mud influence will be dominant, although some compensation can be made for it. The depth of investigation of a single electrode system being small, the device will respond to local changes, such as thin beds; unfortunately, it will be quite sensitive to variations in the drill hole diameter, which will affect the interpretation of the measurement adversely.

Four Electrodes

The other electrode arrangements commonly used in logging have several electrodes in the drill hole, mounted on the sonde. At least one of these electrodes is a potential electrode, and one is a current emitting electrode. The complete circuit involves, in fact, a total of four electrodes, some of the electrodes being placed at a great distance from the sonde itself. If the distant electrode is a potential electrode, it is called a "reference electrode," while if it is a current electrode, it is referred to as a "return ground." When the distant electrodes are sufficiently far away from the sonde, being located at the surface for instance, they are considered to be at electrical infinity and their presence, as far as potential distribution in the vicinity of the sonde is concerned, may be disregarded.

As shown in the illustration, a normal device consists of a potential electrode M placed on the sonde near a current electrode A.[8] The reference potential electrode N is usually at the surface of the ground. The return current electrode B is, for practical reasons, positioned in the hole at some distance from electrodes A and M. Preferably the distance BM should be large as compared to AM, thus giving better defined curves and somewhat greater depth of investigation. The midpoint between A and M is taken as the reference point of measurement to determine the depth of the normal device.

Lateral Device

A lateral device is also shown. In this case three "active" electrodes[9] are placed in close proximity to one another. Two electrodes of the same type, such as current electrodes A, B, are a short distance apart, while a third electrode of a different type, such as a potential electrode M, is at a somewhat greater spacing. An electrode array of this type is not symmetrical and the shape of the curve will usually show it; the peak will often be lopsided. (In these electrode arrangements it is possible to replace the potential electrodes by current electrodes and vice versa, without affecting the resistivity measurement; for instance, the lateral device MAB is fully equivalent to the one shown on the right-hand side AMN, where A and B are electrodes connected in the current source circuit while MN are electrodes connected in the potential measuring circuit.) The middle point between the two closest electrodes in a lateral device is designated as 0. The point 0 is taken as the reference point of measurement to determine the depth of the lateral device.

In the electrode arrangements just discussed, the spacings AM for the normal type and AO (or MO) for the lateral type are important insofar as the depth of investigation is concerned. Although it is not possible to determine explicitly the depth of investigation of a certain device, since it will vary with many factors, in general it may be said that the greater the spacings AM or AO, the greater the depth of investigation.

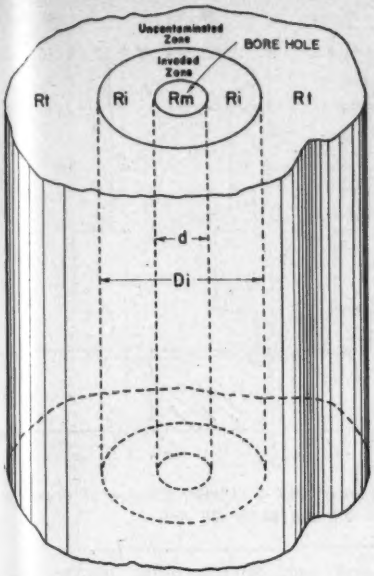


Fig. 2—Schematic representation of conditions in bore hole

meable bed whose pressure is lower than the hydrostatic pressure of the mud at the same depth. The extent of this zone, represented by a cylinder of diameter Di, is also affected by the filtration characteristic of the mud sheath. The mud filtrate mixes with interstitial water and changes its resistivity. In the case of productive horizons, the oil originally present will also be flushed to some extent from the immediate vicinity of the wall of the hole by mud circulation and displacement. This second medium will therefore contain a fluid of somewhat undetermined nature, and its resistivity can be indicated as Ri (resistivity of invaded zone). The third medium will be the uncontaminated formation with a true resistivity Rt.

It is well known that the resistivity of a formation depends on the amount of conductive liquid—electrolyte—it contains, on the distribution of this liquid, and on its resistivity. The conductive liquid in the strata in which we are interested is water with a certain amount of salts in solution. The formation that will contain little or no water will exhibit a very high resistivity such as is found in hard limestone beds. On the other hand, if the formation contains a great deal of conductive water, such as in shale and water sands, the resistivity will be quite low. The relation between the resistivity of a formation and its water content was shown in the Martin, Murray, and Gillingham paper, mentioned above; it was also discussed in several other publications [4,5].

The results obtained by the various investigators were represented in a simple equation by G. E. Archie in a paper published in 1942[6]. If Ro is the resistivity of the permeable formation, 100 per cent saturated with water, and if S is the water fraction of the formation under consideration, the resistivity Rt of that formation will be

$$Rt = \frac{Ro}{S^2} \qquad (1)$$

Furthermore, Archie showed that there existed another relation which would give the resistivity Ro of a permeable formation, where the pore space is entirely filled with water, as a function of the resistivity of the water. This relation is:

$$Ro = FRw \qquad (2)$$

in which the proportionality factor F is called the formation factor.

Going back to the invaded zone shown in Fig. 2, it is rather difficult to say precisely what its resistivity, Ri, will be, in view of the mixture of fluid it may contain. If, very close to the wall of the hole, the mud of resistivity Rm has displaced all of the initial fluid, the resistivity Ri will be:

$$Ri = FRm \qquad (3)$$

Experience has shown that F is usually greater than 4; accordingly, Ri will be appreciably greater than the resistivity of the mud, that is, the resistivity in the bore hole.

At a slightly greater distance from the wall of the hole it is likely that the resistivity of the water in that zone will be intermediate between the resistivity of the interstitial water and the resistivity of the mud. Ri will therefore depend, for that particular zone, on the resistivity of the interstitial water, on the resistivity of the mud and on the amount of interstitial water and mud present.

In the uncontaminated zone, third medium, the resistivity Rt is, from relations 1 and 2,

$$Rt = \frac{FRw}{S^2} \qquad (4)$$

where Rw is the resistivity of the interstitial water and S the water fraction.

It can be seen from a parison of relations 3 and 4 that if Rw is smaller than Rm, and if the water fraction is appreciable in the uncontaminated zone, its resistivity will be lower than the resistivity of the invaded zone. On the other hand, if the water fraction in the undisturbed zone is very low, the resistivity of the undisturbed part will generally be higher than the resistivity of the invaded section.

To summarize, in the case of an invaded formation, three media of widely different resistivity are in contact, with the resistivity of the intermediate medium usually indeterminate. As the resistivity of each medium will play a part in the measurement made with electrodes in the drill hole, the picture is rather com-

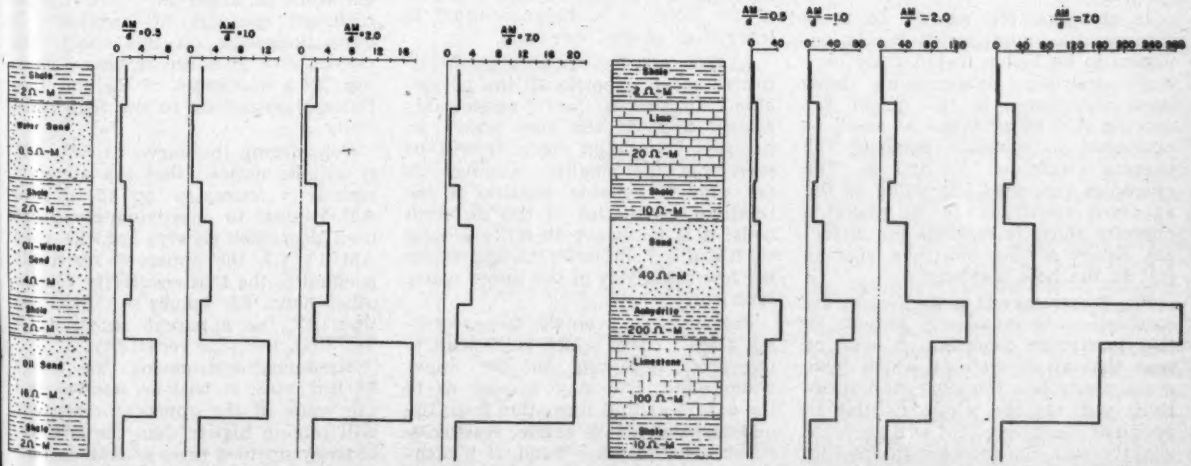


Fig. 3—(Left) Change of apparent resistivity with electrode spacing; Rm = 1Ω — M, no invasion. Fig. 4—(Right) Change of apparent resistivity with electrode spacing; Rm = 1Ω — M. Invasion present: Di = 2d and Ri = 20 Rm

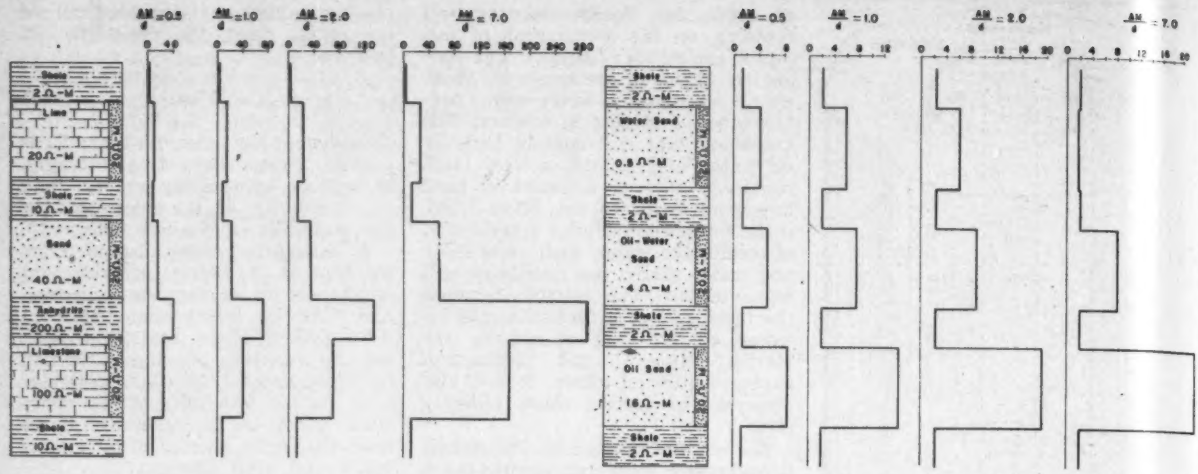


Fig. 5—(Left) Change of apparent resistivity with electrode spacing; Rm = 1Ω—M, no invasion. Fig. 6—(Right) Change of apparent resistivity with electrode spacing: Rm = 1Ω—M. Invasion present: Di = 2d and Ri = 20 Rm

plicated. It is not surprising that, for many types of electrode arrangement, the apparent resistivity Ra will be appreciably different from the true resistivity Rt. Since a quantitative analysis of the log requires the knowledge of Rt, it is therefore necessary to ascertain the difference between Ra and Rt.

Resistivity Departure Curves

Obviously, it is not possible to determine independently the resistivity of an invaded zone, if any, and of the undisturbed formation, as we cannot limit the distribution of the current flowing between the electrodes. However, it is feasible, through proper computation, to determine the apparent resistivity that will be obtained with a certain electrode device under a set of given conditions, for both the normal and lateral device. Mathematical equations have been derived which will give this value of apparent resistivity. Examples showing what can be expected under different cases are given in Figs. 3, 4, 5, and 6.

In the examples shown in these figures, the mud resistivity is assumed to be 1 ohm meter. Only normal electrode arrangements have been considered; in this paper the spacing AM being taken as small as compared to distance between the current electrodes A and B. The examples represent the value of the apparent resistivity to be expected opposite thick formations for different ratios of the electrode spacing AM to the hole diameter d.

Fig. 3 corresponds to the two media case, where no invasion is present. In this particular condition, it will be seen that all formations which have a resistivity less than the mud resistivity will, on the whole, exhibit an apparent resistivity that will decrease slightly with the increase in spacing. On the other hand, all the formations which have a resistivity higher than the resistivity of the mud will yield values of apparent resistivity that will, generally, increase with the spacing.

Examining the curves, it is noticeable that very small spacings will tend to give apparent resistivity values encompassed in a small range. In order to differentiate between low resistivity formations such as water sands and highly resistive formations such as oil sands, the ratio AM/d should at least be 1 and preferably 2. The ratio of AM/d = 2 occurs for a spacing AM = 16 in. if we assume a drill hole with a diameter d of 8 in., and AM = 18 in. for d = 9 in. The ratio AM/d = 7 will correspond to an AM spacing of 63 in. for d = 9 in. These spacings are used quite extensively in electrical logging.

Fig. 4 shows the same series of formations as Fig. 3, where some invasion has taken place in the permeable formations. It has been assumed that the resistivity of the invaded zone is 20 times the mud resistivity and that the depth of this invasion is uniform beyond the wall of the hole, to a distance equal to the radius of the bore hole.

In this case, the apparent resistivities recorded opposite all the permeable formations are appreciably higher than in the case where no invasion had taken place. It will be seen that the smaller spacings do not give a reliable picture of the relative resistivities of the different beds; it is necessary to go to a ratio of AM/d = 7 in order to appreciate the low resistivity of the upper water sand.

Furthermore, even the larger spacing gives a curve which is difficult to interpret. Referring to the upper water sand, one may wonder as to the nature of that formation from the examination of a single resistivity curve. On the other hand, if a comparison is made between the resistivity curve obtained with AM/d = 7 and one of the other curves, the interpretation is much easier and more reliable.

Figs. 5 and 6 deal with formations more resistive than those chosen in the previous examples. Similar remarks can be made concerning the apparent resistivities obtained with other electrode spacings.

The computed values of the apparent resistivities for different sets of conditions have been plotted in such a form that they can be used readily to determine the true resistivity. In the case of noninvaded formations, a series of curves have been established, each related to a certain ratio of true resistivity to mud resistivity. For each curve, the value of the ratio of apparent resistivity over mud resistivity is given for different ratios of electrode spacings over hole diameter. Such curves are called resistivity departure curves.

Examples of such curves are shown in Fig. 7, corresponding respectively to ratios of true resistivity over mud resistivity of: 20, 5, 1, and 0.3. The variation of apparent resistivity for different spacings of electrodes is quite noticeable on this chart. The curves diverge with increased spacings to a maximum of Ra and then become asymptotic to the true resistivity.

Considering the curve Rt/RM = 20, it will be noticed that the apparent resistivity increases up to a ratio AM/d equal to approximately 5 and then decreases slowly. For the ratio AM/d = 1.7, the apparent resistivity is equal to the true resistivity. On the other hand, for values of AM/d less than 1.7, the apparent resistivity is less than the true resistivity.

Similarly, considering the curve Rt/Rm = 0.3, it will be noticed that the value of the apparent resistivity will remain higher than the true resistivity up to a ratio of AM/d equal to approximately 1.3. For greater values of AM/d, up to approximately

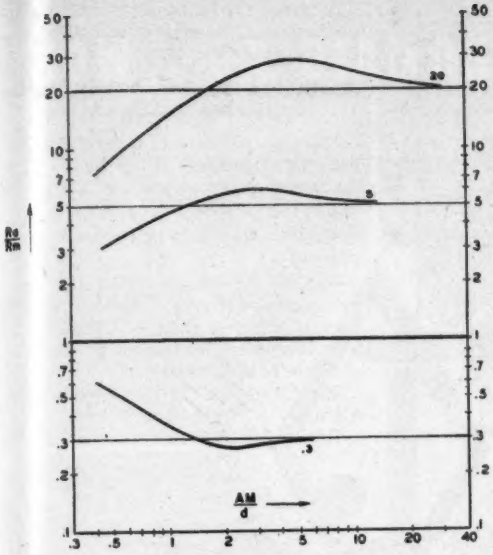


Fig. 7—Resistivity-departure curves, normal device; no invasion; Rt = 0.3,1,5, and 20 Rm

5, the apparent resistivity will be less than the true resistivity.

The above discussion shows that, opposite a given formation, the apparent resistivity may vary widely for different electrode spacings. Accordingly, for accurate analysis of a log, the true resistivity should be used, determining its value from the resistivity departure curves.

Other sets of curves have been computed in cases where invasion of permeable formations is present. Such curves as shown in Fig. 8, also represent the value of the ratio of apparent resistivity over mud resistivity for different values of the ratio AM/d. In this case, each group of curves, plotted on a single sheet of paper, corresponds to a certain value of the ratio of resistivity Ri of the invaded zone over mud resistivity Rm. In addition, for each ratio of true resistivity over mud resistivity several curves are plotted corresponding to different diameters of invasion Di.

The example represented in Fig. 8 deals with the case where the ratio of the resistivity of the invaded zone over the mud resistivity is: Ri/Rm = 20. The departure curves of Ra/Rm have been represented for the respective values of Rt/Rm equal to 0.1, 1, 20, and 100. In each case the curves have been plotted for Di = d (no invasion) and Di =2d.

The apparent resistivity after invasion increases appreciably for all formations where their true resistivity is less than the mud resistivity. This is particularly noticeable for invaded formations having a true resistivity 1/10 that of the mud; in that case, even for relatively small invasion such as Di = 2d, the apparent resistivity may be 50 times the true resistivity, this value occurring for a ratio of AM/d equal to approximately 1½.

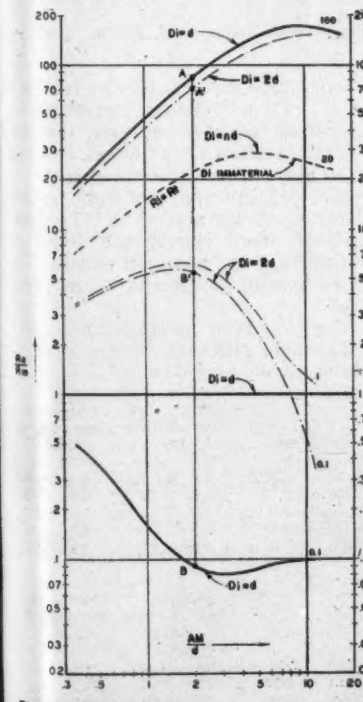


Fig. 8—Resistivity-departure curves, normal device. Invasion present: Ri/Rm = 20

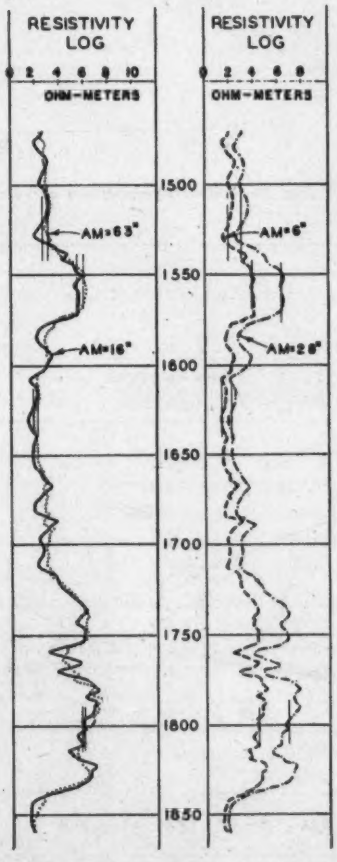


Fig. 9—Resistivity curves opposite noninvaded formations

Fig. 8 illustrates vividly the important effect of invasion upon the value of apparent resistivity. For instance, assuming a spacing AM = 18 in. in a 9-in. hole which corresponds to AM/d = 2, and a mud resistivity of 1 ohm meter, the following remark can be made: For a true resistivity of 100 ohm meters, the apparent resistivity will be about 82 if no invasion is present (curve Di = d, point A), and it is only 70 for an invasion Di = 2d (point A'). For the same spacing and for a true resistivity of 0.1 ohm meter, the apparent resistivity will be 0.09 if there is no invasion (point B), while it becomes 5.4 (point B') if there is an invasion of Di = 2d. In other words, when no invasion is present, the difference in apparent resistivity when going from a true resistivity of 100 ohm meters to 0.1 ohm meter with AM/d = 2 will be represented by the interval AB; as soon as invasion is present, such as Di = 2d, the interval showing the change in apparent resistivity is only A'B'—much less than AB.

The discussion of the foregoing example demonstrates that the effect of mud invasion is to decrease the range of variation of the apparent resistivities measured opposite beds having different true resistivities. The differentiation between the various formations is therefore more difficult as was graphically shown in Figs. 4 and 6.

It would appear, according to Fig. 8, that very large spacings are necessary to distinguish between strata when invasion is suspected. For a good interpretation, based on measurement of apparent resistivity made with a single spacing, a ratio AM/D of at least 20 would be necessary. Such a ratio, in a hole 9 in. in diameter, would mean an electrode spacing of 15 ft. In view of the limitation as to the spacings that can be used, imposed by the effect of bed thickness, it is not practical to use such large spacings.

The resistivity departure curves, however, will give the true resistivity value through the use of relatively short spacings. If the mud resistivity, the hole diameter, the electrode spacings, and the apparent resistivities are known for several electrode devices, a section of curve can be plotted on the chart representing the resistivity departure curves. The line thus determined for a certain formation will fit between some of the curves, having a corresponding gen-

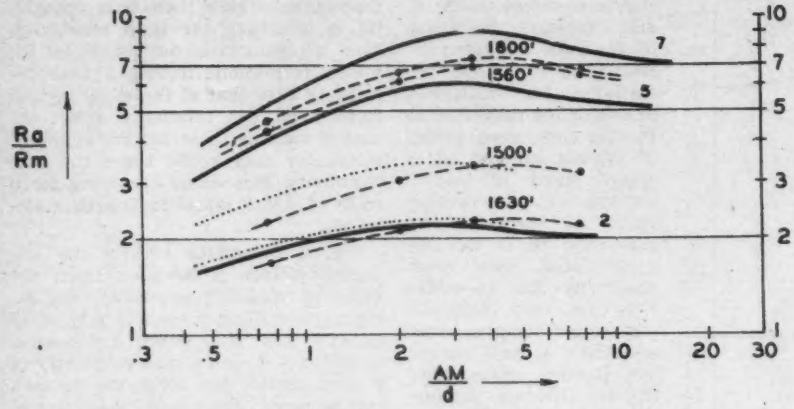


Fig. 10—Resistivity-departure curves for Rt = 2, 5, and 7 Rm, no invasion

able error on its value is not too important and, in some cases, allowance can be made for it.

Application of True Resistivity Determination in Log Analysis

Several examples, taken from actual logs recorded in the field will be discussed to illustrate the use of the resistivity departure curves.

1. Case where mud invasion is not present.

Fig. 9 represents resistivity measurements made in a drill hole with several normal devices. The following data were obtained at the time of the electrical survey:

Bit diameter: 7⅞ in. (assumed hole diameter d is taken as 8 in.).

Rm = 1.3 ohm meter at 76° F., the temperature at 6,100 ft. was recorded as 184° F.; accordingly, correcting for the depth and temperature, the Rm over the section 1,500-1,850 ft. is taken to be approximately 0.9 ohm meter.

Electrode spacings AM were respectively 6, 16, 28, and 63 in. (To demonstrate more clearly the trend of variation of the apparent resistivities, extra spacings of 6 and 28 in. were used.)

The observed average resistivity values over different sections are tabulated as shown below:

Spacings		Shaly section vicinity 1,500 ft.		Sandy section vicinity 1,560 ft.	
AM	AM/d	Ra	Ra/Rm	Ra	Ra/Rm
6-in.	0.75	2.0	2.2	3.9	4.3
16-in.	2.0	2.7	3.0	5.6	6.2
28-in.	3.5	3.1	3.4	6.1	6.8
63-in.	7.9	2.9	3.2	5.9	6.6

Spacings		Shaly section vicinity 1,630 ft.		Sandy section vicinity 1,800 ft.	
AM	AM/d	Ra	Ra/Rm	Ra	Ra/Rm
6-in.	0.75	1.5	1.7	4.2	4.7
16-in.	2.0	1.9	2.1	6.0	6.7
28-in.	3.5	2.1	2.3	6.7	7.4
63-in.	7.9	2.0	2.2	6.1	6.8

eral shape and a corresponding maximum. By interpolation, it will be easy to obtain the true resistivity value. Similar operations can be made for the other formations of interest.

To arrive at a correct answer, it is necessary to have at least two apparent resistivity values and preferably three, in the case where invasion is suspected. These values should correspond to electrode spacings judiciously chosen so that the plotted values will determine a curve much ambiguity.

Not only the slope of the curve is an important factor, but its position on the chart should also be quite definite. Errors in these parameters would give wrong answers. A primary requirement is that the mud resistivity at the depth of the stratum under consideration be obtained accurately. Similarly, the hole diameter should be known although a reason-

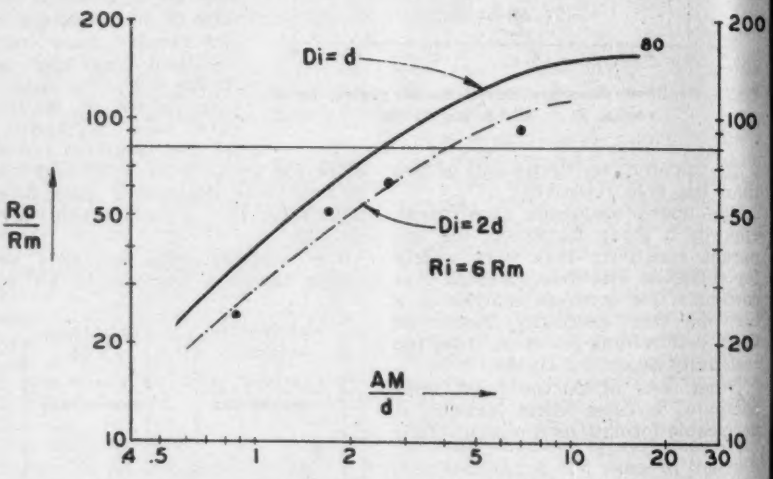


Fig. 12—Resistivity-departure curves; invasion present: Ri/Rm = 6, Rt/Rm = 80

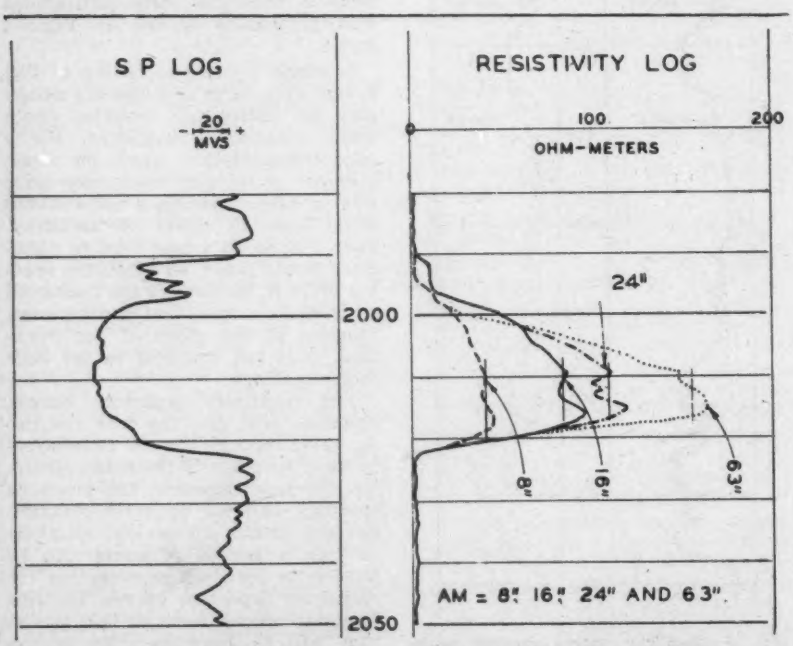


Fig. 11—Electric log recorded opposite an invaded oil-bearing formation

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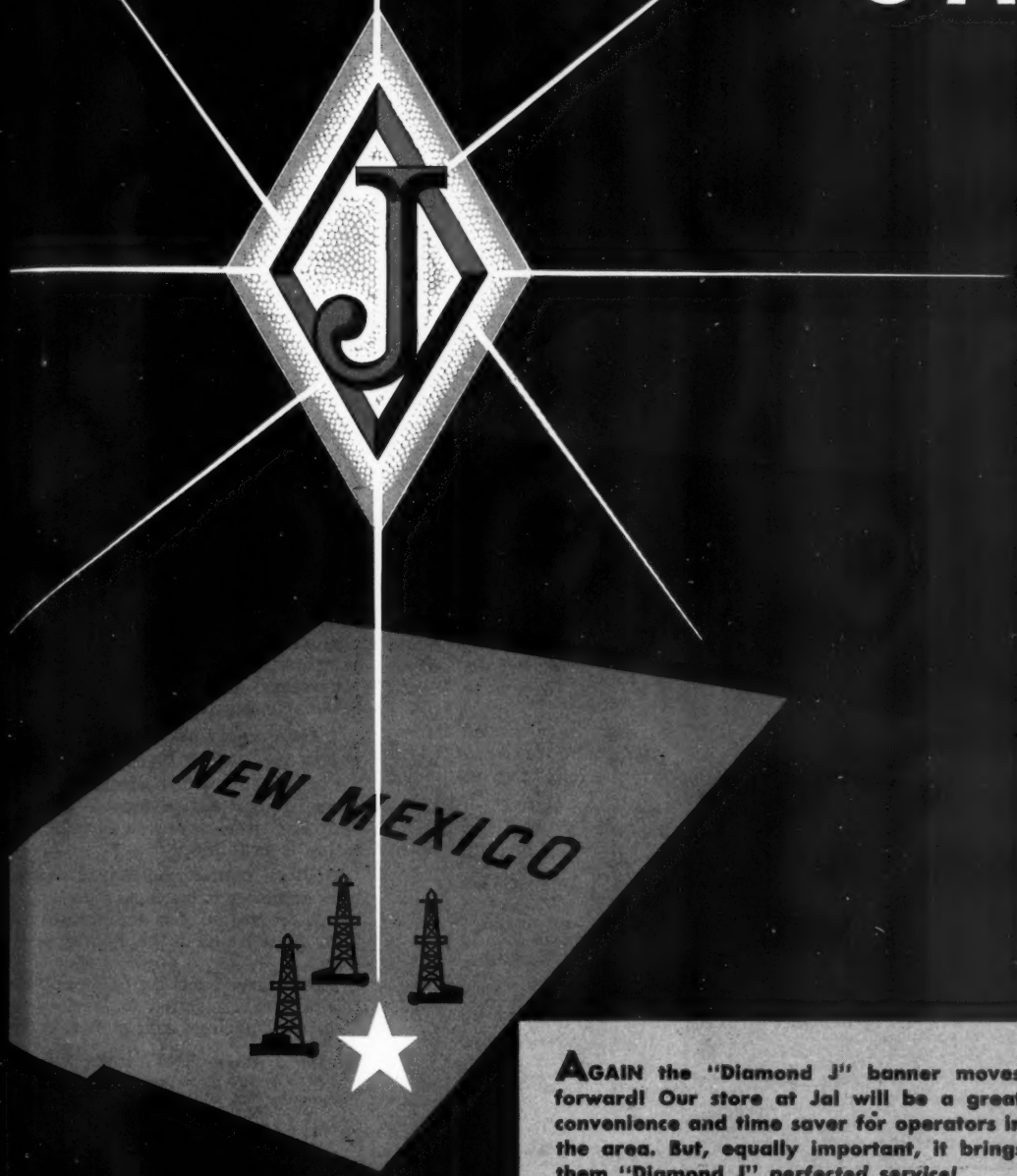

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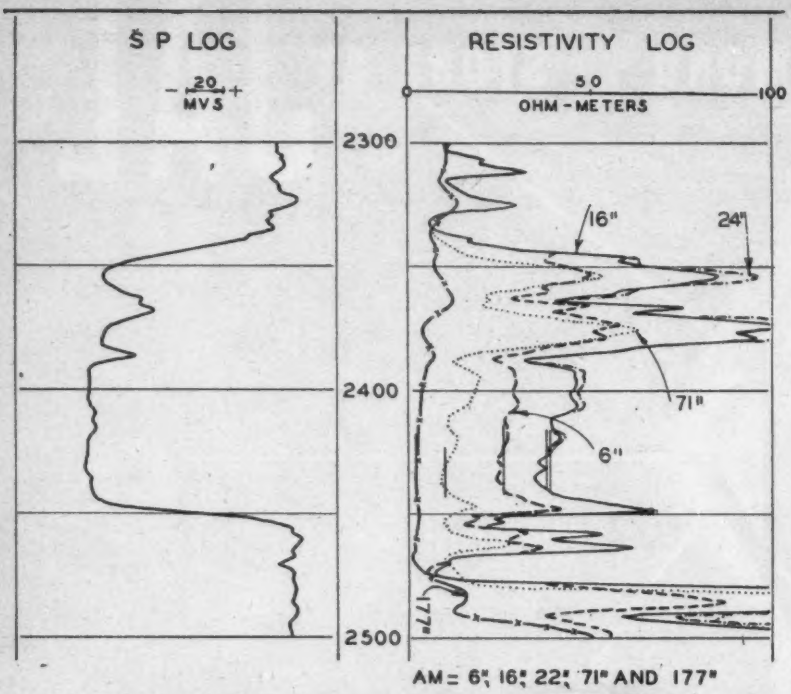

Fig. 13—Electric log recorded opposite an invaded water sand

The ratios of Ra to Rm for different ratios of AM to d are plotted on Fig. 10.

The solid-line curves correspond to resistivity departure curves for Rt/Rm = 2, 5, and 7 ohm meters in the case of no invasion. On the same chart, the measured values of Ra/Rm as a function of AM/d have been plotted; these give the dashed-line curves.

A glance at Fig. 10 will show a good similarity between the two experimental curves (dashed line) determined from the measurements opposite the sandy sections at 1,560 and 1,800 ft., and the two computed curves (solid line) for Rt/Rm = 7 and Rt/Rm = 5.

Extrapolating the observed curves to their asymptotic values of Rt in units of Rm, the following results are obtained:

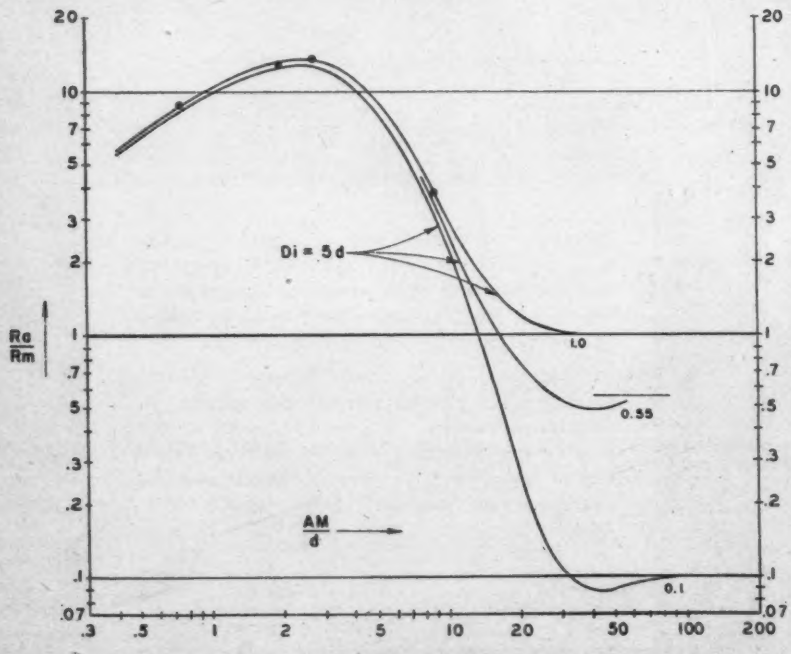

Fig. 14—Resistivity-departure curves; invasion present: Ri = 20 Rm, Rt = 0.1, 0.55, 1.0 Rm

Section around—	Rt/Rm	Rt
1,500 ft.	3.1	2.8
1,560 ft.	5.7	5.1
1,630 ft.	2.1	1.9
1,800 ft.	5.8	5.2

Thus, the true resistivity of the sandy sections in situ is around 5 ohm meters.

If the formation factor of the sand were known, the resistivity of the interstitial water could be determined, since these sandy sections are completely filled with water. The resistivity of the water would be:

$$Rw = 5/F$$

The experimental curves corresponding to the shale sections at 1,500 and 1,630 ft. do not match the computed curves, Rt/Rm = 2 and Rt/Rm = 5, so well, such as the position of the maxima. However, if the dashed curves are moved slightly toward the lefthand side, a striking correspondence is found with the solid curves. Displaced dashed curves are illustrated as dotted lines. The displacement of the experimental curves to insure proper matching is a definite indication that the AM/d values are to high. In other words, as AM was accurately known, the assumed d of 8 in. is too small. In fact, the correct value for d is apparently 14 in. for the shale sections at 1,500 ft. and 1,630 ft.; it is 10 in. for the shaly sands at 1,560 and 1,800 ft. The hole enlargement in the upper part of a well, and particularly opposite shaly formations, is a normal occurrence and corresponds to indications obtained independently.

2. Case where mud invasion is present in oil-bearing formation.

Fig. 11 shows the electric log recorded opposite a permeable resistive bed. The necessary data for interpretation is as follows:

Drill bit diameter: 8¾-in. (assumed hole diameter is taken as 9-in.).

Rm, corrected for temperature at 2,000 ft. is found to be 1.65 ohm meters.

The observed resistivity Ra opposite the permeable section for each of the electrode spacings is as shown below:

AM	AM/d	Ra	Ra/Rm
8-in.	0.89	41	24.8
16-in.	1.7	85	51.5
24-in.	2.7	106	64
63-in.	7	153	93

Plotting the observed values on the departure resistivity curves, it was found that a good correspondence could be had with the computed curve Rt/Rm = 80 and Di = 2d.

The observed points and computed curves are shown on Fig. 12, the curves having been computed for Ri/Rm = 6.

The true resistivity of the permeable formation is therefore approximately 80 times Rm or 132 ohm meters.

The formation factor F was determined in the laboratory from a core and it was found to be 6. According-

ly, one interpretation of the observed curve would be that the mud filtrate effectively displaced the formation fluids, both oil and interstitial water, for a short distance from the wall of the hole. This displacement becomes less complete, of course, the greater the distance from the hole. Thus the resistivity, in successive cylindrical sections beyond the wall of the hole, could range from a value six times that of mud, that is about 10 ohm meters, for complete displacement of the original fluids, to the true resistivity of the undisturbed formation, 132 ohm meters.

For the geological horizon to which the 2,000-ft. section belongs, a true resistivity of 132 ohm meters is a sure indication of oil or gas. If the resistivity of the interstitial water were known, the percentage of the water saturation could now be determined since the formation factor is known to be 6. Assuming a resistivity value for the interstitial water of 0.3 ohm meter at the formation temperature, the water saturation would be around 12 per cent, calculated by using the relationship:

$$S = \sqrt{FRw/Rt}$$

3. Case where mud invasion is present in water-bearing formation.

The third example, presented in Fig. 13, corresponds to a water sand showing an apparent large invasion. In this case:

Drill bit diameter: 7⅞ in. (assumed hole diameter is taken as 8 in.).

Rm corrected for temperature encountered at 2,400 ft. is about 3 ohm meters.

In the lower part of the sand, below 2,400 ft., the average apparent resistivities for the different spacings are as follows:

AM	AM/d	Ra	Ra/Rm
6-in.	0.75	27	9.0
16-in.	2.0	38	12.7
22-in.	2.75	39	13.0
71-in.	8.9	11	3.7
177-in.	22.1	2	0.67

These values were plotted on the resistivity departure curve charts. A good correspondence was found when comparing the observed values to the computed values for Rt/Rm comprised between 1.0 and 0.1, Di = 5d, on the chart Ri/Rm = 20.*

In Fig. 14 the computed curves for Rt/Rm = 1, 0.55, and 0.1 are shown, together with the points corresponding to the observed values. The points agree very well with the curve Rt/Rm = 0.55; hence, the true resistivity of the sand is very close to:

$$Rt = 0.55\ Rm = 1.65 \text{ ohm meters}$$

If it is assumed that, in view of the strong invasion, the sand is completely flushed by the mud filtrate in the vicinity of the hole, then:

$$F = \frac{Ri}{Rm} = 20$$

The low true resistivity 1.65 is a good indication of sand bearing water; therefore:

$$Rt = Ro \text{ and } Rw = \frac{Rt}{F} = \frac{1.65}{20}$$

$$= 0.082 \text{ ohm meter}$$

This value for interstitial water is quite plausible; thus the above assumptions are likely correct.

The appearance of the curve of observed apparent resistivities as a function of the electrode spacing is quite striking. It is rather obvious that, without the help of the resistivity departure curve, it would have been practically impossible to arrive at an approximate figure for the value of the true resistivity.

In the particular example, a very large spacing was used to show clearly the variation of the Ra with the spacings. Without using a spacing larger than 71 in., the general trend of the curve would nevertheless have

*The value Ri/Rm = 20 was chosen because the formation factor for this sand in this area is close to 20.

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been obtained. The results would have shown that the Rt/Rm could not be higher than 1; that is, the true resistivity could not exceed 3 ohm meters. With a formation factor of 20, this value indicates a water-bearing formation.

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- Explosion Proof, designed for installation in Class 1, Group D, Division 2, Hazardous Locations.
- Provides short circuit, single phase, overload, undervoltage, bearing temperature and oil pressure motor protection.
- Safe—Metal enclosed.
- Shipped as complete unit, reducing time of installation and field labor to a minimum.
- Quick replacement of breakers by using semi-draw-out.

Our Engineers are specialists with long experience in the design of Electrical Equipment for the Petroleum Industry and are available for consultation with your engineers in planning equipment to meet the most exacting requirements of Pipe Line Companies for both Standard and Custom-Built Electrical Equipment.

NELSON ELECTRIC MANUFACTURING CO.

217 North Detroit — TULSA, OKLAHOMA — Telephone 2-5131

MANUFACTURERS OF:

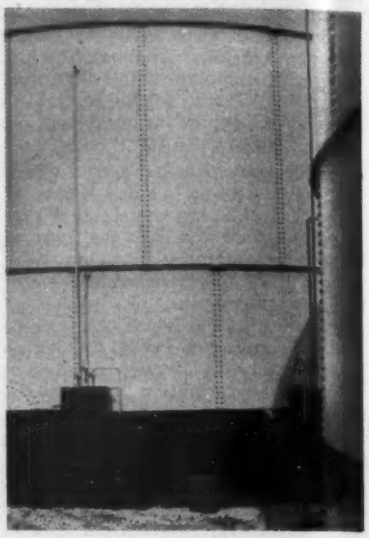
Explosion Proof Motor Controls
Junction Boxes and Enclosures
Circuit Breakers and Lighting Panels

Oil Field Motor Controls
Automatic Pipe Line Sampling Devices
Cathodic Protection Equipment

Switchboards
Instrument and Control Panels
Unit Substations

Triple Sampling Piping for Tanks

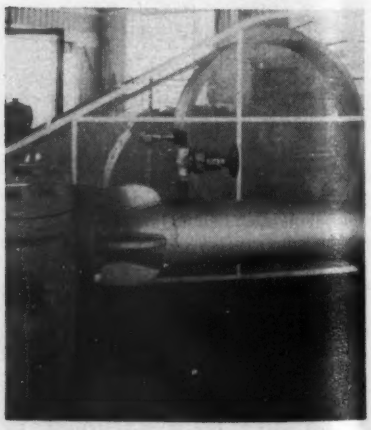
PROVISION has been made by the pipe-line department of a California company for drawing samples from three levels in a large crude-oil



tank. By means of three drawoff lines samples of crude oil for gravity determinations can be drawn, from a point 12 in. from the bottom, from a halfway point, and from 18 in. below the roof of the tank. The tank in the illustration serves a Huntington Beach, Calif., pipe-line pump station.

Reinforced Discharge Line

DISCHARGE pressures of 700 psi. at a West Texas pumping station have caused the operators to reinforce



the discharge lines on the pumps. Four steel fins have been welded to the discharge line as shown in the photograph. These reinforcing fins prevent possible damage from vibration if the tanks and suction are pumped dry.

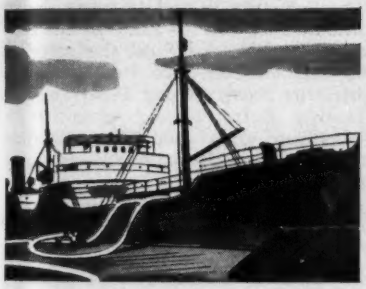
CORROSION

is no problem when you use

UCILON

USERS TELL US Ucilon* 400 resists *more* corrosives for *longer* periods than any other coating tried! And it's especially suited to the severe service conditions found in the oil industry—as shown by remarkable endurance records on tankers, in the field, in storage tanks. If you have a job too tough for paint, we want it. For we believe plastic-based Ucilon 400 will outlast all other coatings you have tried—and cut your maintenance costs as well.

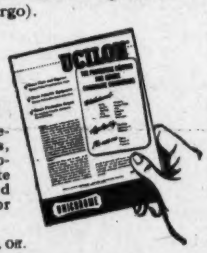
FACTS ON SERVICE



UCILON 400 was tried in a tanker's hold, which carried 100-octane gasoline, diesel oil, kerosene, salt water ballast. The hold was flushed with live steam before each cargo change. Yet Ucilon coatings were still in excellent condition *after 10 months!* (No previous coating had survived even one cargo).

SEND FOR THIS BULLETIN

It gives you more details on properties, types of coatings, application data. Write your nearest United Chromium office for your copy.



*Trade Mark Reg. U. S. Pat. Off.

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WITH THE *MIGHTY PUNCH!*

FOR FIRE HAZARDS THAT DO NOT DEMAND LARGER EQUIPMENT . . .

The new ANSUL 4 Dry Chemical Fire Extinguisher has fire stopping effectiveness far in excess of any other extinguisher of comparable size. Its compact size makes it ideal for locations where space is limited. The ANSUL 4 is easy to use . . . easy to recharge on-the-spot . . . and again ready to

STOP FIRE FASTER!

MADE BY THE MAKERS OF ANSUL-DUGAS DRY CHEMICAL FIRE EXTINGUISHERS, MODELS 20, 30, 150A AND 350A.

ANSUL CHEMICAL COMPANY

FIRE EXTINGUISHER DIVISION, MARINETTE, WISCONSIN

QUESTIONS on TECHNOLOGY

by W. L. Nelson

Consulting Engineer

Friction Loss in Stacks

In The Refiner's Notebook No. 135 you quote a friction-loss formula for stacks which is given in several handbooks, etc., but which gives values four times larger than indicated by other formulas. Can you explain this apparent inconsistency? J.O.T.

No satisfactory explanation can be given here but it was felt that our readers should be aware of the great differences in pressure drop by different formulas. J.O.T. has studied the situation and finds that the formula used in the Notebook No. 135 of March 15, 1947:

$$h = \frac{fLu^2}{DT} = \left(\frac{.008}{T}\right)\frac{Lu^2}{D}$$

is also stated in Cochran's Handbook (Third edition, page 212), Gebhardt's Steam Power Plant Engineering (Sixth edition, page 304), and by Alfred Cotton in the June 1923 issue of Buildings. In addition Babcock & Wilcox's "Steam" (Thirty-fifth edition, page 239) presents a formula that gives about the same results.

In contrast, Walker, Lewis and McAdams "Principles of Chemical Engineering" (First edition), Perry's "Chemical Engineers Handbook" (Second edition, page 805), Crane Co.'s "Flow of Fluids" and Cameron Pump Co.'s "Hydraulic Data" (Eleventh edition, page 92) state the basic Fanning or Darcy equation:

$$F = \frac{2fLu^2}{gD} = (.0622f)\frac{Lu^2}{D}$$

In both of these formulas the units of L, u, and D are the same (i.e. feet and feet per second) but the "h" is inches water, the "F" is feet of fluid flowing, and the "f" in Fanning's equation has a different value from that in the empirical equation. The constants of the equations should be equal, i.e.:

$$\frac{62.4}{p} \times \frac{.008}{12T} = 0.0622f$$

in which "p" is the density of the gas and "T" is the absolute temperature ° F.

The constants of the equations are not equal. The empirical formula gives values four times larger than the Fanning equation. Gebhardt shows the derivation of the empirical formula from Chezy's expression which is the same as that of McAdams, but he uses a friction factor of 0.016 instead of 0.004 in arriving at the factor of 0.008 used in the empirical formula. It is possible that the friction loss is abnormally large in stacks or chimneys but it is not impossible that an error has been repeated through these many years.

American Pipe Standard

We are told to use Schedule 80 pipe. What is such a pipe?—R. R. S.

A new pipe standard became tentative practice in 1935 and was formally adopted in 1939 by the American Standard Association (29 West 39th Street, New York) as A.S.A.—B 36.10. This standard replaced the common Standard, Extra Strong, and Double Extra Strong terms, by 10 schedule weights as shown in Table 1. The Schedule 30 and 40 items shown in bold face are the same as the now obsolete Standard Pipe, the schedule 60 and 80 bold-face items are the same as Extra Strong Pipe, and the Double Extra Strong classification has been abandoned. The schedule numbers are approximately equal to the expression:

$$1000\frac{P}{S}$$

in which P is the internal pressure (psig.) and S is the allowable fiber stress (psi.).

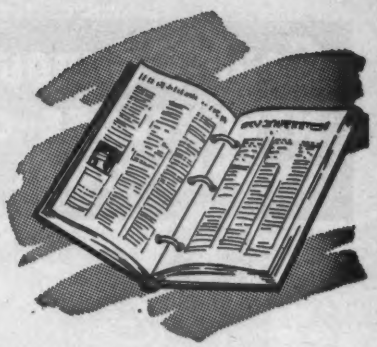
TABLE 1—DIMENSIONS OF WELDED AND SEAMLESS STEEL PIPE

Nominal pipe size	Outside diameter	Nominal wall thickness for schedule numbers: Sched. 10	Sched. 20	Sched. 30	Sched. 40	Sched. 60	Sched. 80	Sched. 100	Sched. 120	Sched. 140	Sched. 160
⅛	0.405	....	....	....	**0.068**	....	**0.095**	....	....	....	....
¼	0.540	....	....	....	**0.088**	....	**0.119**	....	....	....	....
⅜	0.675	....	....	....	**0.091**	....	**0.126**	....	....	....	....
½	0.840	....	....	....	**0.109**	....	**0.147**	....	....	....	0.187
¾	1.050	....	....	....	**0.113**	....	**0.154**	....	....	....	0.218
1	1.315	....	....	....	**0.133**	....	**0.179**	....	....	....	0.250
1¼	1.660	....	....	....	**0.140**	....	**0.191**	....	....	....	0.250
1½	1.900	....	....	....	**0.145**	....	**0.200**	....	....	....	0.281
2	2.375	....	....	....	**0.154**	....	**0.218**	....	....	....	0.343
2½	2.875	....	....	....	**0.203**	....	**0.276**	....	....	....	0.375
3	3.5	....	....	....	**0.216**	....	**0.300**	....	....	....	0.437
3½	4.0	....	....	....	**0.226**	....	**0.318**	....	....	....	....
4	4.5	....	....	....	**0.237**	....	**0.337**	....	0.437	....	0.531
5	5.563	....	....	....	**0.258**	....	**0.375**	....	0.500	....	0.625
6	6.625	....	....	....	**0.280**	....	**0.432**	....	0.562	....	0.718
8	8.625	....	0.250	0.277	**0.322**	0.406	**0.500**	0.593	0.718	0.812	0.906
10	10.75	....	0.250	0.307	**0.365**	0.500	**0.593**	0.718	0.843	1.000	1.125
12	12.75	....	0.250	0.330	**0.406**	0.562	**0.687**	0.843	1.000	1.125	1.312
14 o.d.	14.0	0.250	0.312	0.375	0.437	0.593	0.750	0.937	1.062	1.250	1.406
16 o.d.	16.0	0.250	0.312	0.375	0.500	0.656	0.843	1.031	1.218	1.437	1.562
18 o.d.	18.0	0.250	0.312	0.437	0.562	0.718	0.937	1.156	1.343	1.562	1.750
20 o.d.	20.0	0.250	0.375	0.500	0.593	0.812	1.031	1.250	1.500	1.750	1.937
24 o.d.	24.0	0.250	0.375	0.562	0.687	0.937	1.218	1.500	1.750	2.062	2.312
30 o.d.	30.0	0.312	0.500	0.625	....	....	....	....	....	....	....

All dimensions are given in inches. Thicknesses shown in bold type in Schedules 30 and 40 are identical with thicknesses for "standard weight" pipe in former lists; those in Schedules 60 and 80 are identical with thicknesses for "extra strong" pipe in former lists. The schedule numbers indicate approximate values of the expression 1,000 × P/S. The decimal thicknesses listed for the respective pipe sizes represent their nominal or average wall dimensions. For tolerances on wall thicknesses, see appropriate material specifications.

The Refiner's Notebook

A WEEKLY FEATURE OF THE OIL AND GAS JOURNAL



Pump Operation

PRACTICAL suggestions are so numerous that only a few points can be enumerated.

Reciprocating pumps.—Slow speeds (1) allow long life, (2) require fewer line repairs, (3) produce fewer leaks, (4) require less steam, (5) cause less water hammer, (6) allow more of a suction lift, and (7) promote long strokes or larger capacity.

Long-stroke pumps (even 2½ times liquid cylinder diameter) operate more smoothly, the cylinders are filled more completely, and they require less repair.

Select pumps that have deep stuffing glands and with holding or tightening nuts on the stuffing box that are readily available.

Centrifugal pumps.—Any unusual noise in a motor indicates trouble. Look for a "bum" that may mean that the pump is "frozen" somewhere as by impeller obstruction, too-tight glands, or locked bearings.

Examine and replace the glands at regular intervals rather than at breakdown.

Do not overfuse the motor; find the reason for the extra power required.

No gland will "stay in" if the pump is operated too long at closed discharge.

Do not depend on a flexible coupling to care for poor alignment.

The two boxes on this page are taken primarily from the Standard Oil Co. of New Jersey. Preventative Maintenance Course, which was described on page 48 of the July 22, 1944, issue of The Oil and Gas Journal.

MOTOR-DRIVEN CENTRIFUGAL PUMPS

STARTING

A. Check lubrication, close main switch, see that discharge is closed. (Starting up with open discharge valve overloads motor. Large valves may be cracked open from one to one and a half turns.)
B. Open suction valve, try bleeder for liquid.
C. Try shaft by hand, if possible, to be sure it is free. Press starter button. Notice discharge pressure.
D. Open discharge valve slowly, check pressure reading.

STOPPING

A. Close discharge valve slowly.
B. Press stop button. If the motor does not stop, turn off main switch and report.
C. Close suction valve.

When motors have been idle for some time watch them closely.

Follow any special department rules and note any special tags or instrument plates.

THESE THINGS INDICATE TROUBLE	WHAT CAN BE DONE
1. Motor won't start	Check main switch; try by hand; notify foreman.
2. Slow in getting up to speed	Feel bearings to see if hot; check discharge valve; check tightness of packing; notify foreman.
3. Motor trips out continuously	Use spare pump—notify foreman.
4. Noisy motor (be sure and notice)	Use spare pump—notify foreman.
5. Motor smokes	Shut down—check lubrication—use spare—notify foreman.
6. Pump loses suction	Shut down—check to see that you have liquid—start up as tabulated above but taking particular care with Step B. Bleed until vapor is expelled.
7. Motor runs when stop button is pressed	Turn off main switch and report.
8. Power interruption stops motor	Close discharge valve. Do not start up until notified.
9. Hot motor bearing or stuffing box	Check lubrication—loosen packing gland follower.

STEAM DUPLEX PUMPS

STARTING

Step 1. Open suction, then discharge valves. Use goggles, if chemicals.
Step 2. Check open drips, examine lubricator, oil valve gear.
Step 3. Open exhaust valve to heat cylinders, and drain exhaust line.
Step 4. Drain live steam line and crack live steam throttle valve.
Step 5. Close drips when dry steam appears.
Step 6. Open throttle valve and bring up to speed slowly.

STOPPING

Step 1. Close throttle valve.
Step 2. Close exhaust valve.
Step 3. Open all drips.
Step 4. Close suction and discharge valve.
Step 5. Follow any special departmental rulings.

THINGS TO AVOID	RESULT
1. Overspeeding (see rates below)	Waste of steam—broken parts
2. Control of flow with discharge valve	Steam waste—wire-drawn valve—excessive wear.
3. Throttled exhaust valve	Steam waste—wire-drawn valve—excessive wear.
4. Loss of suction	Steam waste—broken valves, springs, etc.
5. Uneven gland adjustment	Scored rods, scored sleeves.
6. Open top oil containers	Dirty oil—scored cylinders.
7. Leakage of product	Oil loss from evaporation.

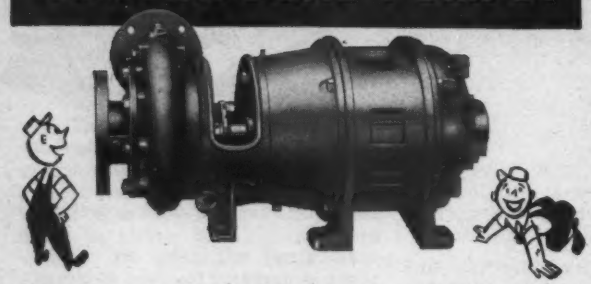
RECOMMENDED SPEED FOR VARIOUS SIZE PUMPS

(Does not apply for heavy liquids, such as fuel oil, tars, etc.)

Size of pump	R.p.m.	Size of pump	R.p.m.
3 by 2 by 3	80	12 by 10 by 18	37
7½ by 5 by 6	65	15 by 10½ by 18	37
7½ by 5 by 10	48	12 by 7 by 20	35
10 by 6 by 12	45	16 by 14 by 24	30

No. 162 in a series by W. L. Nelson, professor of petroleum refinery engineering, University of Tulsa

Goulds announces . . .
NEW "CLOSE-CUPLD" CENTRIFUGAL PUMPS!

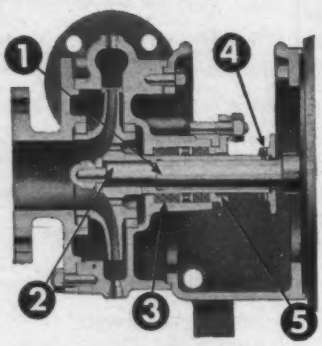


17 sizes . . . Capacities up to 2000 GPM . . . for almost any service!

Drawing upon 100 years of pump design and manufacture, Goulds presents a new line of "Close-Cupld" Centrifugals which give you improved pumping efficiency, simpler maintenance and longer life. Through standardization, wearing parts are interchangeable for pumps of varying sizes. This minimizes spare parts, an important advantage where various size pumps are operating.

Designed for a broad range of service, the field for these new Goulds "Close-Cupld" Pumps is almost unlimited. With heads up to 400 feet, depending on capacities, there is a "Close-Cupld" Pump for almost every condition.

NEW "CLOSE-CUPLD" FEATURES



1. Shaft sleeve covers full length of shaft . . . compression seals between shaft sleeve and impeller hub and sleeve and shoulder on shaft completely protect shaft from liquid damage.
2. Shaft sleeve is free to expand or contract with temperature changes —prevents buckling, distortion.
3. Machined stuffing box designed for *die-formed*, semi-metallic packing or mechanical seal . . . gives you operating flexibility.
4. Liquid deflector, mounted on end of shaft sleeve, is drilled and tapped so that in servicing pump it can be used to prevent shaft rotation while removing or tightening impeller nut; also, to remove sleeve . . . a time saver.
5. New split gland simplifies repacking of stuffing box, when necessary another time saver.

Contains complete specifications (ASTM designations), full efficiency and horse power ratings of each pump, all dimensions necessary to make a layout.

GET THIS BULLETIN!

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DEPT. OG-9, SENECA FALLS, N. Y.
Please send me your new "Close-Cupld" Bulletin 710-1.

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COMPANY_____
ADDRESS_____
CITY_____ ZONE____ STATE_____

GOULDS PUMPS, INC.
SENECA FALLS, N. Y.
the PUMP FOR *the* JOB

BETTER JOINTS ALL WAYS . . . WITH X-L LINE PIPE COUPLINGS

Our special process of recessing "X-L" Line Pipe Couplings assures perfect alignment, tighter joints and protection of vanishing threads, giving longer life to the line. Made in strict accordance with A.P.I. standards in all sizes, black or galvanized. Comparator-tested to maintain absolute accuracy.

Save time, eliminate error: Use our catalog description when ordering.

WHEELING MACHINE PRODUCTS COMPANY
WHEELING · WEST VIRGINIA

MORE PROFITS COMING UP with a JENSEN

A Jensen will lift no more oil than the pump will handle. But in each barrel that comes up is a little more profit—due to lower maintenance costs, more efficient use of power and less wear and tear on polish rod, stuffing box and other parts.

And these additional profits add up to quite a pile of jack over a Jensen's long service life.

Look into these extra profits by contacting your Jensen dealer—or write today to—

JENSEN Bros. Mfg. Co.
Coffeyville, Kansas, U. S. A.

Export Office: 50 CHURCH STREET, NEW YORK CITY

MODERN Rotary DRILLING

Internal-Combustion Engines

MORE than half of all the rotary rigs now in operation in this country are powered by internal-combustion engines using gas or butane as fuel. The remainder are divided among steam, diesel-mechanical, diesel-electric, and purchased electric-power rigs. This predominant position as a prime mover of rotary rigs has been attained by the internal-combustion engine in the relatively short time of less than 20 years. The progress has been primarily at the expense of the steam rig. The contributing causes were the economy of operation as far as fuel and water consumption is concerned, and increased portability of a power rig as compared with a steam rig. The disadvantages resulting from inherent characteristics of internal-combustion engines have been overcome to a considerable extent by providing means for proper transmission of power to different component parts of the rig.

Problems resulting from the increasing depth of wells have been met by increasing the size and the number of engines used. There have been no radical changes in the design of drilling engines during the last few years. The improvements made were primarily in the type of materials used and in details of design. A modern internal-combustion engine, used in rotary drilling service, is designed to handle the rapidly changing load demands and to withstand severe conditions of oil-field hauling and moving. It requires a minimum of attention and maintenance. It is conservatively rated with a resulting long operating life. Fig. 36 gives power, torque, and fuel-consumption characteristics of a typical large internal-combustion engine used for drilling operations.

Synchronization.—Means of compounding of individual engines are provided in a power rig, permitting any desired distribution of the total power among the different portions of the rig or concentration of all the available power for any one operation. Compounding is to be considered in following installments of this series. From the standpoint of the prime mover itself, compounding requires synchronization of the compounded engines, if efficient distribution of loads is to be attained. If the speeds of the individual engines are not closely synchronized, one of the engines may be overloaded and may actually have to pull another engine or engines.

To attain engine synchronization, use may be made of the engine intake-manifold vacuum. This vacuum is an approximate indication of the percentage of load that the engine is carrying. Special throttles have been developed using manifold vacuum for proper distribution of load among two or more engines. Arrangements must be made for a system which permits selective synchronization of the engines. For instance, in drilling, one of the engines may drive the rotary at a different speed from the two other engines which are synchronized and compounded to drive the mud pump. Then in hoisting all three engines may be compounded and their speed must be synchronized.

Fuel.—Fig. 37, based on data of one engine manufacturer, gives fuel consumption of internal-combustion engines for different fuels and different percentages of loading.

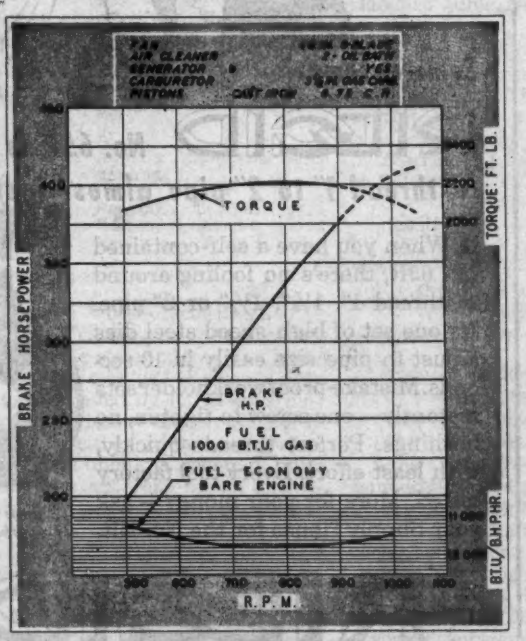


Fig. 36—Left: Power, torque, and fuel consumption characteristics of a typical internal-combustion drilling engine

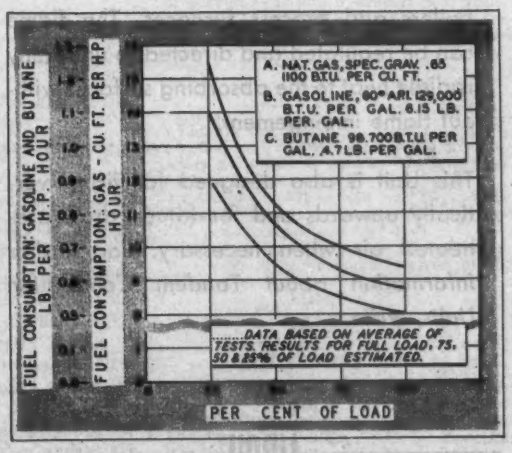
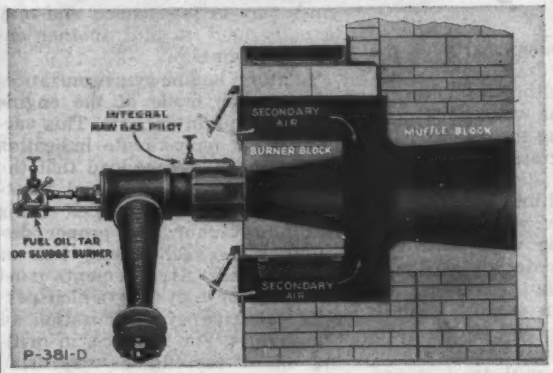

A. NAT. GAS, SPEC. GRAV. .65 1100 B.T.U. PER CU. FT.
B. GASOLINE, 60° A.R.I. 129,000 B.T.U. PER GAL. 6.15 LB. PER. GAL.
C. BUTANE 98,700 B.T.U. PER GAL. 4.7 LB. PER GAL.
DATA BASED ON AVERAGE OF TESTS. RESULTS FOR FULL LOAD, 75, 50 & 25% OF LOAD ESTIMATED.
FUEL CONSUMPTION: GASOLINE AND BUTANE LB. PER H.P. HOUR
FUEL CONSUMPTION: GAS - CU. FT. PER H.P. HOUR
PER CENT OF LOAD

Fig. 37—Below: Fuel consumption of internal-combustion engines for different fuels and for different percentages of loading

No. 38 in a series by Joseph Zaba, petroleum engineer, Houston

NATIONAL AIROIL FUEL OIL · GAS BURNERS

TANDEM COMBUSTION UNIT



maintains a high flame temperature with either fuel oil or gas . . .

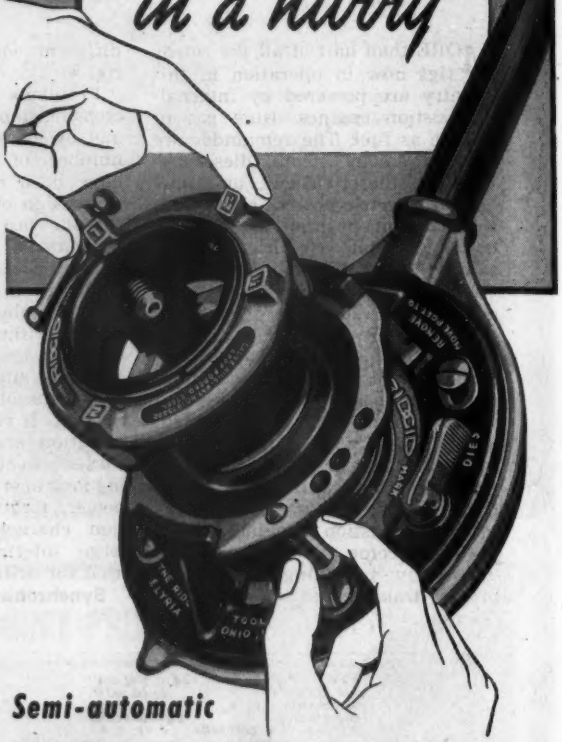
and is easily "lighted off" in a cold furnace with fuel oil or gas. It can be brought, quickly, to full capacity with a clean flame; has a high turndown ratio with a steady flame; and can be applied to all types of boilers and process furnaces. The flame can be regulated and directed to uniformly radiate heat to the absorbing surfaces without flame impingement.

This Unit is also designed for firing vertically upwards and for forced draft preheated air when necessary. *For further information about Tandem Combustion Units, write*

AIROIL

Main Offices & Factory: 1238 EAST SEDGLEY AVENUE, PHILADELPHIA 34, PA.
Texas Office: 2nd National Bank Bldg., Houston

PERFECT PIPE THREADS *in a hurry*



Semi-automatic

RIDGID ***No. 65R is ready to thread 1" to 2" pipe almost instantly***

● When you have a self-contained No. 65R, there's no fooling around to thread 1", 1¼", 1½" or 2" pipe. Its one set of high-speed steel dies adjust to pipe size easily in 10 seconds. Mistake-proof workholder sets instantly — one screw to tighten, no bushings. Perfect threads quickly, with least effort. Every tool factory tested. More for your money — ask your Supply House for the No. 65R.

It stands up handily on the floor.

RIDGID

WORK-SAVER PIPE TOOLS

THE RIDGE TOOL COMPANY · ELYRIA, OHIO

ENGINEERING fundamentals

Reservoir Fluids: Behavior of Gases

ON the basis of the kinetic theory of gases, one can arrive at a law giving the relationship existing between pressure, volume, and temperature for a given mass of a gas. This relationship, called the Perfect Gas Law, mathematically is:

$$PV = nRT \qquad (1)$$

where

P = absolute pressure on the gas
V = volume which it occupies
T = absolute temperature of gas
n = the number of mols of gas, equal to its mass divided by its gaseous molecular weight, and
R = the gas constant

From this relationship a volume can be calculated if number of mols, pressure, and temperature are known. Units in the above relationship must, of course, be consistent. Usually the consistency in units is arranged with the gas constant, R, which is numerically the same for all gases. Values of R for the pressure, temperature, volume, and mols in certain units are:

P	V	T	n	R
Atm.	cc.	°Absolute Centigrade Scale	gram-mols	82.05
Atm.	cu.ft.	°Rankine	lb.-mols	0.729
Psi.	cu.ft.	°Rankine	lb.-mols	10.71
(*)	cu.ft.	°Rankine	lb.-mols	1,544

*Pounds per square foot.

Perhaps a word of clarification is necessary concerning the definition of mols. As stated above, the number of mols of gas is equal to its weight divided by its gaseous molecular weight. Since weight is given in either pounds or grams, depending upon the system of units used, two different molar quantities are possible, either pound-mols or gram-mols. For example, methane, CH_4, has a molecular weight of 16. Therefore, 32 lb. of methane is equal to 2 pound-mols, or 32 grams of methane is equal to 2 gram-mols.

The perfect gas law reduces to Boyle's Law,

$$P_1V_1 = P_2V \qquad (2)$$

when the temperature is constant, and to Charles' Law,

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \qquad (3)$$

when the pressure is constant.

The perfect gas law states that one mol of any perfect gas will occupy the same volume at a given pressure and temperature. This is a convenient relationship and we thus utilize 359 cu. ft. as the volume occupied by 1 lb.-mol of any perfect gas at one atmosphere and 32° F., and 379 cu. ft. as the volume occupied by 1 lb.-mol of any perfect gas at one atmosphere and 60° F. This relationship allows the engineer to convert rapidly from standard cubic feet to pound-mols or vice versa.

Density of any substance is defined as mass per unit volume of the substance. Thus, density of a perfect gas at a given temperature and pressure can be arrived at by rearranging the perfect gas law as follows:

$$\text{density} = \frac{m}{V} = \frac{P \times M}{RT} \qquad (4)$$

where

m = the mass of the gas under consideration and
M = molecular weight of the gas

This states that density varies directly with pressure at a given temperature and inversely with temperature at a given pressure.

Since density does vary with temperature and pressure, it is not a very convenient physical quantity to use to characterize a gas. A more convenient term is specific gravity, which is defined generally as the ratio of the density of a substance to the density of a standard substance. For gases, air is usually used as the standard. The density of air is also variant with pressure and temperature, so both must be specified. Then it is most convenient to define the specific gravity of a gas as the ratio of its density at a given temperature and pressure to the density of air at the same temperature and pressure. Thus, specific gravity will be independent of pressure and temperature.

From the perfect gas law, the density of air is

$$d_{air} = \frac{P \times 28.96}{RT} \qquad (5)$$

where 28.96 is the apparent molecular weight of air. Dividing this into Equation 4 for gas density, gives for the specific gravity,

$$\text{S.G.} = \frac{d_{gas}}{d_{air}} = \frac{M}{28.96} \qquad (6)$$

This equation states that specific gravity as defined above can be calculated from the molecular weight of the gas alone, and is not dependent upon pressure and temperature.

Example 1: What is the density of propane gas, formula C_3H_8, in pounds per cubic foot at 100° F. and 30 psig.?

Solution: Equation 4 is used. Since density is required in pounds per cubic foot and the pressure is in pounds per square inch, the value of R to use will be 10.71. The molecular weight is found from the formula C_3H_8. Carbon has an atomic weight of 12 and hydrogen of 1. Therefore, $(3 \times 12) + (8 \times 1) = 44$, the molecular weight. Therefore,

$$\text{Density} = \frac{44.7 \times 44}{10.71 \times 560}$$

$$= .328 \text{ lb. per cu. ft. at 30 psig. and 100° F.}$$

Example 2: What is the specific gravity of ethane gas, formula C_2H_6?

Solution: The molecular weight is found as above from the atomic weight of carbon = 12 and hydrogen = 1. Thus, $M = (2 \times 12) + (6 \times 1) = 30$. The specific gravity is then found from Equation 6.

$$\text{S.G.} = \frac{30}{28.96} = 1.035$$

which is the value for specific gravity of ethane at any temperatures and pressures at which it can be considered a perfect gas.

Example 3: What will be the volume in cubic feet occupied by 1,000 lb. of air at 3 atmospheres and 150° F.?

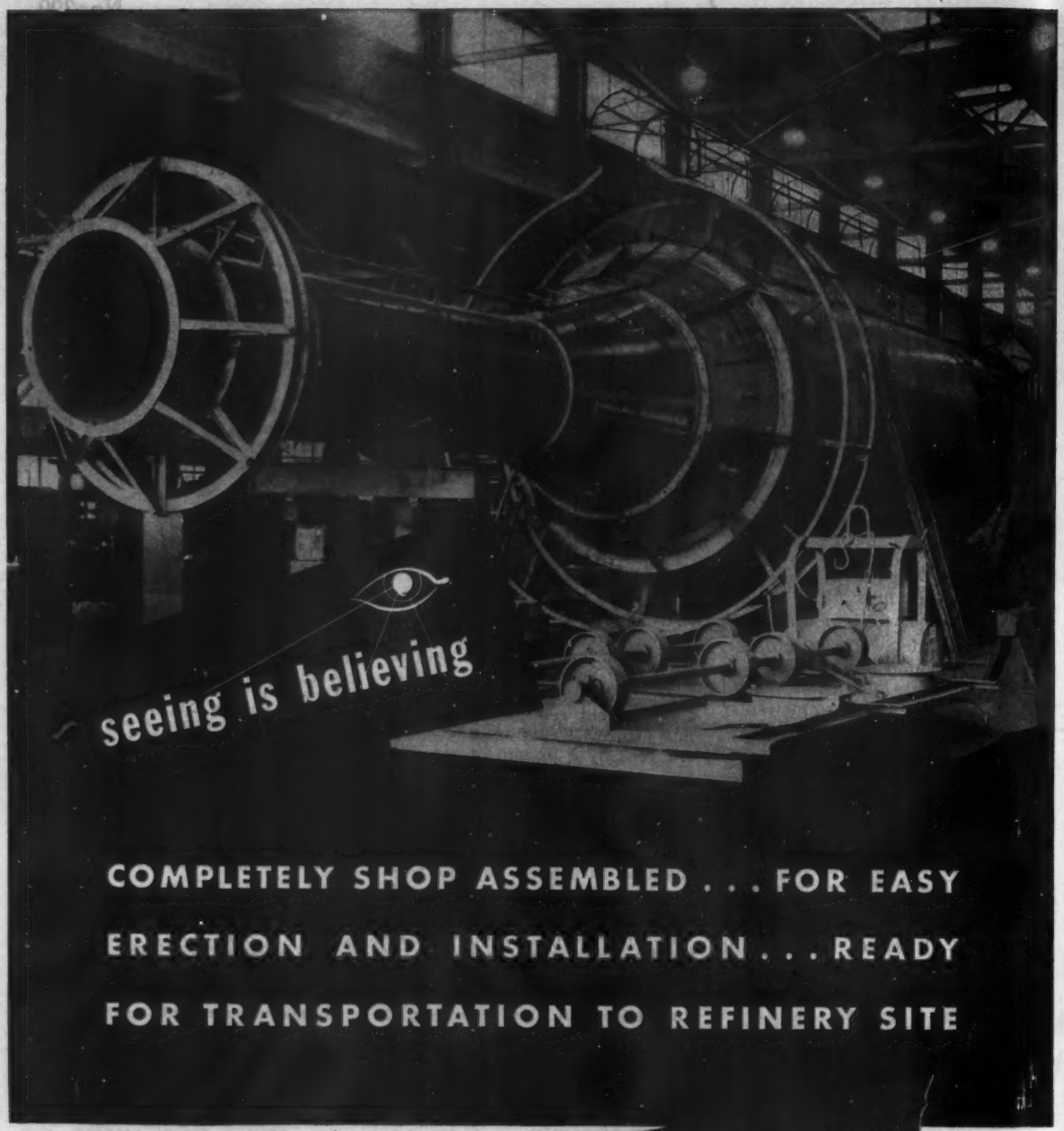
Solution: Using Equation 1, and taken R = 0.729 since pressure is given in atmospheres,

$$3 \times V = \frac{1,000}{28.96} \times 0.729 \times 6.0$$

$$V = 5,110 \text{ cu. ft.}$$

Nomenclature: P = Pressure; V = Volume; n = Mols; R = Gas Constant; T = Temperature; m = Mass; M = Mol Weight; d = Density; S.G. = Specific Gravity.

Series prepared by Dr. John C. Calhoun, Jr., Petroleum Engineering School, University of Oklahoma



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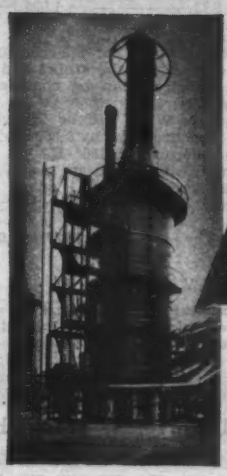

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REFINING

Throughput of Imperial Plant to Be 6,500 Bbl.

EDMONTON, Alta.—H. H. Hewetson, president of Imperial Oil, Ltd., has announced that the Imperial Oil refinery to be erected at East Edmonton will have an initial throughput of 6,500 bbl. daily.

Reerection of the plant at Whitehorse, Yukon, purchased from War Assets Administration for $1,000,000 (U.S.), will not commence for several months, owing to the long haul from the original site to a railhead at Dawson Creek, B. C.

During the coming winter, 50-ton trailer trucks will be used to haul portions of the plant over the frozen Alaska Highway. G. S. Davis, of Sarnia, Ont., will have charge of the shipment and reerection of the plant at Edmonton. Railway spurs are now being laid.

Crude from Canada's new and promising Leduc field will be used to charge the refinery when in operation at Edmonton. Moving and reerecting the plant is costing Imperial Oil an additional $6,000,000 to $7,000,000. *(The Oil and Gas Journal, August 23, page 141).*

Imperial Oil's pipe line from Leduc field to Nisku on the Calgary-Edmonton Canadian Pacific Railroad branch line is expected to be in operation early in October. Construction involves 8 miles of 8-in. main line, with gathering lines already completed to all Imperial producers, comprising 2 miles each of 6-in. and 4-in. and 3 miles of 3-in.

The 8-in. main line now under construction will be carried on a 500-ft. suspension bridge over a deep coulee between the field and Nisku. From the latter point the oil will be moved by rail to the Imperial refineries at East Calgary and Regina.

Oronite Chemical to Double Phthalic Anhydride Output

A plant expansion program which will double its present production rate of phthalic anhydride has been announced by Oronite Chemical Co., San Francisco.

George L. Parkhurst, president of Oronite, a Standard Oil Co. of California subsidiary, said construction will start in the next few weeks to enlarge the company's Richmond plant.

The increased output will be available during the first half of 1948, Parkhurst said. Principal present market for phthalic anhydride is as a base for alkyd resin paints. Oronite's plant was the first to derive phthalic anhydride from petroleum and it is the only operation of its kind on the Pacific Coast.

N.L.G.I. Prepares Program For Chicago Convention

A number of technical papers are scheduled on the program of the fifteenth annual convention of the National Lubricating Grease Institute October 16-18 at the Edgewater Beach Hotel in Chicago.

Official call for the meeting has been issued by H. P. Hobart, Gulf Oil Corp., Pittsburgh, institute president. Technical papers will be presented at the morning and afternoon sessions October 16, and the morning session October 17. The program has been arranaged by James R. Corbett, Cato Oil & Grease Co., Oklahoma City.

The list of speakers includes Dale V. Stingley, Armour & Co., Chicago, discussing, "Fats, Oils, and Fatty Acids for Industrial Purposes;" C. E. Pritchard, Republic Steel Corp., Cleveland, "Grease Lubrication in Steel Mills;" S. B. Elliott, Ferro Chemical Corp., Cleveland, discussing "Metallic Soap;" D. H. D. Haas, Purdue University, Lafayette, Ind., speaking on "Atomic Energy;" and J. A. Altshuler, Stratford Engineering, and Claude Johnson, Jareco, Inc., both of Kansas City, Mo., whose subject is "Pressure Soap Contractors and Hot-Oil Circulation Heating System."

An hour of fellowship the evening of October 17 will be followed by the annual banquet.

The technical committee under the chairmanship of Carl W. Georgi, Enterprise Oil Co., Buffalo, N. Y., will use afternoon of October 17 and the morning of October 18 for a symposium on "Pumpability of Grease and Delivery Characteristics of Dispensing Equipment." This is a further exploration into the subject which claimed the technical committee's attention last year. The discussion material was published in bulletin form following last year's convention and made available from N.L.G.I.'s headquarters, 4638 Mill Creek Parkway, Kansas City 2, Mo. It is planned that the same procedure will be followed this year.

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institute will be held at 4:30 p.m., October 17.

Jet Engine Efficiency Test Devised by Shell

An improved method of determining the efficiency of jet-engine performance has been developed at the jet-engine laboratory of Shell Oil Co., Inc., at Wood River, Ill., according to C. E. Davis, vice president of manufacturing. Technicians at the laboratory, he said, have also discovered major causes of carbon deposition in jet engines.

Efficiency of jet engines is measured at Wood River by a new method of analyzing exhaust gases. Jet engines have presented special problems because only an infinitesimal quantity of unburned fuel remains in the exhaust, mixed with tremendous quantities of air, Davis said. Shell scientists, therefore, have had to perfect new methods of quantitative gas analysis.

As an additional refinement, the laboratory has devised means for running continuous tests of exhaust gases. The new analytical techniques have been made available to others interested in jet fuels.

Davis said that under improper conditions of jet-fuel use, so much carbon is deposited that the airplane engines must be overhauled every 5 to 10 hours. Laboratory tests at Wood River reveal that chief factors affecting this deposition are: (a) fuel composition; (b) fuel volatility; (c) intake temperature; (d) method of introducing fuel; and (e) conformation of the combustion chamber. Experiments indicate that "carboning up" can be reduced by altering these factors.

The laboratory, whose opening was announced March 1945, includes a jet burner that produces 250 times as much heat as a residential-type oil burner and creates a stream of hot gases traveling at extremely high velocity. Compressed air is supplied by a 1,000-hp. compressor. Both miniature and full-scale engine burner tubes enable comprehensive studies of fuel performance.

Bright-Stock Output Shows 11 Per Cent Increase

Production of 13 companies which manufacture lubricating oils in the midwestern area showed an increase of 29,716 bbl. in the production of bright stock for July over that of June. July's output was 285,715 bbl., an increase of more than 11 per cent.

Other increases were in steam refined stock and blended oils, the former showing an increase of 5,101 bbl. for July's output or nearly a 16 per cent increase over the previous month. Production of blended oils increased from 546,880 bbl. for June to 562,747 bbl. for July which represents less than a 3 per cent gain.

Viscous neutrals production decreased from 522,467 bbl. for June to 481,831 bbl. for July, nearly 8 per cent. Paraffin oils also were down from 90,118 bbl. to a total of 82,047 bbl. for July, a drop of 9 per cent.

Figures compiled by the Western Petroleum Refiners Association are based on the operations of the 13 companies.

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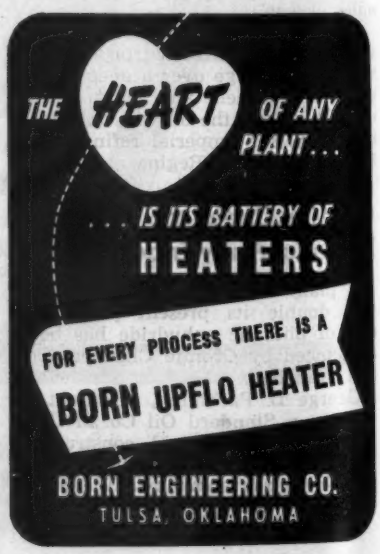
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PIPE LINES

Stanolind to Complete Hamilton Dome Line Soon

Stanolind Pipe Line Co., early this week had finished half of the 12-mile, 8-in. crude-oil line from Hamilton Dome, Hot Springs County, Wyoming, to a connection with the company's Elk Basin system. The line will be completed October 1. Following completion of the line, production from the Hamilton Dome field will be increased 4,000 bbl. to a total of 11,000 bbl.

The letting of a contract for 74.4 miles of 20-in. looping between La Plata, Mo., and the Mississippi River, known as Job 1, of the current looping project, will be delayed until the company can determine when there will be sufficient pipe available to start construction. The date predicted for this is now October 15. The pipe originally intended for Job 1 was allocated to Jobs 2, 3, and 4 now under construction between the Mississippi River and Manhattan, Ill., in order to expedite progress during the early part of the undertaking. On September 11, the spreads working on Jobs 2, 3, and 4 reported that 15½ miles had been laid, including 6 miles of 20-in. and 9½ miles of 22 in.

When the La Plata-Manhattan gap in the big-inch looping of the main line is filled by the 20-in. and 22-in. looping scheduled for completion by the end of this year, Stanolind will have a continuous 20-in. and 22-in. line from Drumright, Okla., to Whiting, Ind.

Sunray Pushes Work on Beckett-Velma Line

Sunray Oil Corp. is laying 15 miles of 6-in. from Beckett to Velma, Okla., which is to be completed October 15. This provides a connection between Beckett refinery and the Texas Pipe Line Co. pump station at Velma.

A dual line will be laid later along the Bechett to Velma right-of-way which will be extended approximately 79 miles from Velma to Sunray's refinery at Allen. Final connection with the Allen plant facilities will be effected January 1, 1948. The entire project is estimated to cost more than $1,000,000. This completed line, together with other lines, will deliver at the rate of 20,000 bbl. of crude oil daily to Sunray's Beckett refinery. Three pump stations are to be built: one at Beckett, one at Allen, and the third at Wynnewood. These are being constructed for pumping in reverse directions during alternate months for charging stock going to Beckett and for furnishing products pumped via Allen through Sunray's line to the connection with the Great Lakes Pipe Line system.

Last Welds Made for "Biggest Inch" Line

The final welds to complete Southern California Gas Co.'s and Southern Counties Gas Co.'s 214-mile, 30-in. line were made early this week by H. C. Price Co., contractor for the entire project.

The operating companies are reported to have a program for filling the line with natural gas in order that it may serve as a reservoir to be drawn on to meet peak-load conditions in the next few weeks. The connection of the "biggest inch" line at Blythe, Calif., with the 26-in. line being built from Texas will be made later this year.

Interstate Awards River Crossing Contract

Interstate Oil Pipe Line Co. let contract for a Canadian River crossing to Oklahoma Engineering Co. of which F. E. Warterfield, Jr., is president, and T. L. Jones is vice president. The crossing will consist of 3,300 ft. of 12-in. laid 5 ft. below the stream bed on 50-mile, 12-in. line which Interstate is building from Oklahoma City to the Maysville pool.

Work on the project is being pushed to take advantage of the present period of low water in order that the crossing may be ready in advance of the construction of the overland line which it is to serve.

New York State Natural Inch Connection Approved

WASHINGTON.—The Federal Power Commission has authorized New York State Natural Gas Corp. to construct and operate facilities which will enable it to receive deliveries from the Big and Little Big Inch lines.

The company has been issued a certificate of public convenience and necessity permitting construction and operation of a new 6,000-hp. compressor station and connections and

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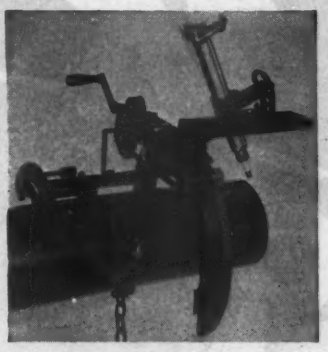

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1.1 miles of 20-in. connecting lines, overall cost of which is $1,313,785.

These facilities, which the FPC has already authorized on a temporary basis, are designed to enable New York State Natural to add up to 75,000,000 cu. ft. of gas per day to its capacity.

The projected connection with the Inch lines is in Greene County, Pennsylvania.

Shell Pipe Line Honored By Four Safety Awards

During the past week ceremonies for presentation of four safety awards by U. S. Bureau of Mines officials have been conducted in three divisions and at the Houston headquarters of Shell Pipe Line Corp.

"We are proud to acknowledge the action of the Joseph A. Holmes Safety Association in presenting four certificates to Shell Pipe Line Corp.," said H. H. Anderson, vice president and general manager. "These are in recognition of no lost time because of accidents in the period ended December 31, 1946: Wasson-Hobbs division, 846 days, 463,835 man-hours; Austin division, 846 days, 455,127 man-hours; Healdton division, 772 days, 542,086 man-hours; Shell Pipe Line Corp., 128 and 121 days, 1,105,000 and 1,025,275 man-hours in 1946."

Operations involved covered those of both the crude-oil lines of Shell Pipe Line Corp. and the products managed by Shell Pipe Line Corp.

Out of 32 such awards presented to the petroleum industry, a total of eight awards for 1946 records went to employes in the operations of Shell interests. Of these, the four awards mentioned went to the 1,450 employes of Shell Pipe Line Corp. Last year Shell Pipe Line Corp. received the National Safety Council's Distinguished Service to Safety Award of Honor.

Plans Revived for 220-Mile Swedish Products Line

Svenska Entreprenad Aktiebolget is studying plans for a 220-mile products pipe line from Uddevalla through Vanersborg to Vasteras for handling shipments from the west coast of Sweden to a point approximately 100 miles northwest of Stockholm.

Originally planned before the war, the project is being revived to provide more economical transportation for the area. Pumping is to be done with 20-stage Byron Jackson Hydro Press-type pumps with submersible motors. Pumps will have 70 per cent efficiency. Suctions of the pumps will take products directly from the pipe line without use of balancing tanks. Discharge pressure will be 520 psi. above the suction pressure. The pump

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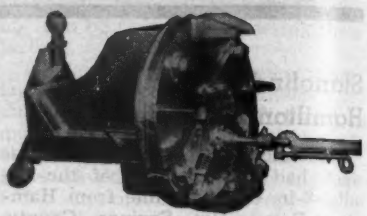

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and motor for each unit is to be inclosed in a steel cylinder about 20 ft. long and 20 in. in diameter, which would be lowered into an underground chamber where it would be grouted in place.

The proposed line will have delivery facilities at Vanersborg, Lidkoping, Laxa, Askersund, Hallsberg, and Koping as well as Vasteras.

The project has been planned to utilize pipe of the following diameters: 5-in., Uddevalla-Vanesborg; 4-in. for the remainder of the main line with a 3-in. lateral to Askersund.

Several interests now engaged in distribution of petroleum products are reported to be cooperating in this undertaking. The project would be operated as a common carrier.

During summer months it is expected products from the line would be transshipped by boat to various points on the lakes in the area to be traversed by the line.

Two Spreads Working on Beaumont-Hearne Line

Early this month a second spread started from Hearne, Tex., to work south on Magnolia Pipe Line Co.'s 178-mile, 12-in. products line from Beaumont. Another spread has been working northward from Beaumont.

It is expected that the two spreads will meet to complete the line by the middle of October. The contractor operating both spreads is Smith Contracting Corp. which is making extensive use of units of pipe-line construction equipment operating on their own power. Such equipment is fabricated at the shop of O. R. Smith Manufacturing Co., Fort Worth.

Oklahoma Natural Reconditioning Line

Oklahoma Natural Gas Co. is reconditioning 14 miles of 8 and 10-in. pipe on the line from Crescent field to a point southeast of Enid, Okla.

The company is also taking up and reconditioning 19 miles of 16-in. near Boynton, Okla.

East Houston Tanks Built For Texas Pipe Line Co.

Work is under way for the construction of tank grades and levees for ten 122,000-bbl. tanks as well as roadways and culverts at the East Houston tank farm of the Texas Pipe Line Co. Work is being done by Vilbig Construction Co.

Welding School Held for Pipe-Line Projects

Materials are being donated by major companies to assist the operation of a welding school conducted at the Chamblee, Ga., shops of Williams Brothers Corp. The purpose of the school is to train welders to work on pipe-line projects in various areas.

There are 14 students in training. It is the intention of the school to complete training of students at the rate of 10 per month. From 6 weeks to 2 months is required for training, depending on the aptitude of the student.

There is no charge for tuition. Students are not paid. No previous experience in pipe-line construction is required of the young men accepted for training.

Southern Natural Plans Pipe-Line Expansion

Construction of additions and extensions to the southern pipe-line system of Southern Natural Gas Co., a subsidiary of Federal Water & Gas Corp., is being planned from the proceeds of a $5,000,000 loan.

The Securities and Exchange Commission has approved a proposal of the Southern Natural Gas Co. to sell $5,000,000 of 2-year, 1¾ per cent promissory notes to 13 banks.

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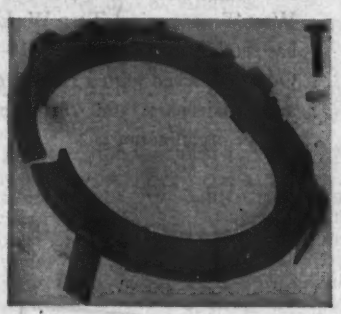

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NATURAL GAS

A.G.A. Natural-Gas Group Plans Convention Session

THE Natural Gas Department of the American Gas Association has scheduled an afternoon meeting October 7 during the A.G.A.'s twenty-ninth annual convention October 6-8 in Cleveland, Ohio.

Program for the department session in the Euclid Ball Room of the Hotel Statler includes addresses by Max W. Ball, director of the Oil and Gas Division of the Department of Interior; W. F. McConnor, vice president, National Tube Co.; and Dr. A. W. Gauger, Pennsylvania State College.

In addition to the October 7 meeting, the department is sponsoring the appearance of Nelson Lee Smith, chairman of the Federal Power Commission on the program of the convention general session the morning of October 7. Smith will speak on "Regulation of Gas Utilities."

The program for the Natural Gas Department meeting follows:

TUESDAY, OCTOBER 7

2 p.m.—"Opening Remarks," Robert W. Hendee, chairman, Natural Gas Department, and president, Colorado Interstate Gas Co., Colorado Springs, Colo.; Report of Nominating Committee, R. H. Hargrove, chairman, and president, Texas Eastern Transmission Corp., Shreveport, La.; Time and Place of 1948 Spring Meeting, Charles E. Bennett, chairman, and president, Manufacturers Light & Heat Co., Pittsburgh, Pa.; "Development of Standards for Testing Gaseous Fuels," Dr. A. W. Gauger, Penn State College, Penn State, Pennsylvania, chairman, Committee D. 3, American Society for Testing Materials; "Fuels for Today and Tomorrow," Max W. Ball, director, Oil and Gas Division, U. S. Department of the Interior; "Present and Prospective Outlook for Steel Tubular Goods," W. F. McConnor, vice president, National Tube Co., Pittsburgh.

Natural - Gas Department Committee Meetings.—Managing and Advisory Committees, dinner, October 7, 6:30 p.m. Rose Room, Hotel Cleveland; Nitrogen Removal Subcommittee, October 6, 2:00 p.m., Parlor D, Hotel Statler; Pipe-Line Flow Subcommittee, October 6, 2:00 p.m., Parlor M, Hotel Statler; Technical and Research Committee, Luncheon, October 7, 12:30 p.m., Parlor C, Hotel Statler.

Pacific Coast Association To Meet Next Week

Construction of the Texas-California pipe line, developments in the atomic-energy field, catalytic synthesis of gas from coal, the gas industry's new sales promotion plans are among the principal subjects of interest scheduled for the fifty-fourth annual meeting of the Pacific Coast Gas Association September 23-25 at the Coronado Hotel in San Diego.

The program includes a number of entertainment features as well as the business sessions. Election of officers is scheduled for the afternoon session September 23. A color motion picture showing work on the Texas-California line will be shown the morning of September 24. The annual banquet will be the evening of September 25.

Opening talks the afternoon of September 23 will be by LeRoy M. Edwards, president, Pacific Coast Gas Association, and R. H. Hargrove, president, American Gas Association. Other speakers listed for the meeting include: Paul Kayser, president, El Paso Natural Gas Co.; Alden G. Roach, president, Consolidated Steel Co.; Harold P. Huls, president, California Public Utilities Commission; Dr. Lee A. Du Bridge, president, California Institute of Technology; Harold Costello, L.P.G. marketing specialist, Standard Oil Co. of California; D. A. Hulcy, president, Lone Star Gas Co.; Frank H. Lerch, Jr., president, Consolidated Natural Gas Co.; E. S. Pettyjohn, director, Institute of Gas Technology; Guy W. Wadsworth, Jr., vice president, Southern California Gas Co.; John Robertshaw, president, Robertshaw Thermostat Co.; and H. Leigh Whitelaw, managing director, Gas Appliance Manufacturers Association.

July Natural-Gas Sales Show 8.8 Per Cent Gain

Sales of natural gas during July totaled 1,722,067,000 therms, a gain of 8.8 per cent over July 1946, according to the monthly report of the American Gas Association.

The A.G.A. index of natural-gas sales stood at 205.9 per cent of the 1935-1939 average on July 31, 1947. For the 12-month period natural-gas sales were 24,567,774,000 therms, an increase of 10 per cent over the like period a year earlier.

Total sales of gas utility companies of all types—natural, mixed, and manufactured—to ultimate consumers in July were 1,945,809,000 therms, an increase of 8.2 per cent over the comparable month last year. The A.G.A. index of total gas sales on July 31, 1947, stood at 198.8 per cent of the 1935-1939 average. For the 12-month period ending July 31, 1947, total sales of gas were 28,331,526,000 therms, an increase of 10.4 per cent over a year ago.

Three Alabama Cities Getting Gas Systems

A new modern natural-gas system has been placed in operation by the city of Atmore Ala. The system consists of approximately 20 miles of 6-in. transmission line and about 20 miles of distribution line, owned by the city of Atmore which will buy gas from United Gas Pipe Line Co.

The system was designed and constructed by the organization of Ray R. Littrell, contractor, of Opelousas, La. The same organization is building similar plants for the cities of Flomaton and Brewton, Ala.

Natural Gasoline

Five Papers Listed For C.N.G.A. Fall Meeting

West Coast fuel problems, use of centrifugal compressors, and the delivery of natural gas from Texas to California are among the subjects to be discussed October 10 at the fall meeting of the California Natural Gasoline Association at the Ambassador Hotel in Los Angeles.

Five papers are scheduled on the program for the 1-day meeting. The program has been arranged by a committee headed by R. S. Ridgway, Standard Oil Co. of California, as chairman.

Speakers and topics for the C.N.G.A. meeting are:

"Adaptability of Centrifugal compressors to Gasoline-Plant Operations," Dan McDonald, Magnolia Petroleum Co.; "Motor-Fuel Sensitivity," E. J. McLaughlin, California Research Corp.; "Cycling at High Pressures vs. Depletion and Cycling at Low Pressures," E. O. Bennett, consulting engineer; "Future Outlook for B.t.u.'s in California," Marion Dice, General Petroleum Corp.; and a description of El Paso Natural Gas Co.'s operations in connection with the delivery of natural gas to California, by C. L. Moore, El Paso Natural Gas Co.

Shell and Coltexo to Expand Wasson Plant

Shell Oil Co., Inc., and Coltexo Corp. will begin construction soon on an extension of their jointly owned Wasson No. 2 gasoline plant as a step toward further utilization of gas produced in Wasson field for Yoakum and Gaines counties, Texas.

The extension is designed to process an additional 24,000,000 cu. ft. of gas daily from Wasson pool. Present amount processed is about 75,000,000 cu. ft. daily. Completion is scheduled for early 1948.

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Exploration and Drilling

A 100-Million-Barrel Discovery?

RECENT developments at Elk Basin, on the Wyoming - Montana border, indicate strong possibilities that the Madison lime (Mississippian), a deeper pay, may prove to be another 100-million-barrel proven reservoir. The Pennsylvanian Tensleep at shallower depth is now estimated at around 200 million barrels ultimate; the Madison would be in addition to that.

Last December Stanolind Oil & Gas Co. on behalf of the Elk Basin Unit, deepened a well on top of the structure, 38-M Unit, NE SE NE 24-58n-100w, drilled Madison lime from 4,340-5,013 ft., and after casing off 340 ft. of upper section with good saturated zones, completed in the lower part for 247 bbl. daily.

Just recently Sinclair-Wyoming Oil Co. 1 Wilkins, NW SW NW 28-9s-23e, across the border in Montana, topped Madison at 6,215 ft., drilled to 6,795 ft., acidized, and flowed 745 bbl. in 11 hours through a 5/16-in. tubing choke on 2½-in. tubing.

Now the second well in the Elk Basin Unit area, Stanolind 95-M Unit, NE NW SE 31-58n-99w, about 2½ miles southeast of discovery well, and about 5 miles southeast of the Sinclair-Wyoming producer, swabbed 28 bbl. per hour for 20 hours. This well topped Madison at 5,029 ft., drilled out of it at 5,937 ft., to total depth of 5,941 ft. in shale. There was no water in the entire Madison section, 908 ft. thick.

The Sinclair well on the north is 1½ miles northwest of the nearest Tensleep producer, and on part of the structure that in upper horizons is in a separate fault block.

Some geologists believe that the fault hay have died out before reaching the base of the Tensleep sand, and that there is a good possibility that the Madison lime will lie like a blanket over a large part of the huge structure. Others estimate that of the 17,784 acres in the Tensleep Unit area, about 75 per cent can be considered proven at this stage.

What is obvious is that over an area 5 miles long, three wells have found very thick sections of the Madison, with the water level undetermined downstructure and perhaps no water at all in the Madison above the oil-water contact level as finally determined on the flanks. Currently an agreement has been reached by which all three wells will be produced at the rate of 1,000 bbl. per day. This will probably involve opening up the upper part of the pay in the discovery well, 38-M Unit.

The rate per well agreed upon is indication that geologists and engineers think they have a tremendous reservoir, with a very low water level.

EASTERN TEXAS

Hopkins County Test To Go on Pump

DALLAS.—Delta Drilling Co. 1 W. H. Coker, sub - Clarksville discovery 3 miles southeast of Reilly Springs, in Hopkins County, had the rig down and were installing pumping unit. Total depth was 4,210 ft., plugged back to 4,168 ft. Casing perforations are at 4,150-65 ft. With tubing set at 4,167 ft., it was swabbed down to 2,800 ft., making an undisclosed amount of clean oil, but it would not flow. Oil then rose to within 500 ft. of the surface. There was no water with the oil and estimated gravity is 25°.

In Freestone County, 1 mile southwest of Stony Point Church, The Texas Co. 1 Irwin was completed for an open-flow potential of 23,000,000 cu. ft. of gas a day, plus 3½ bbl. of 49.8°-gravity distillate, from perforations in the Pettit limestone at 8,132-46 ft. It is an extension to Pettit production in Teague field.

Stanolind Oil & Gas 1 George Slaughter, Harrison County test 8 miles northeast of Marshall, was preparing to perforate at 6,850-60 ft., after squeezing off at 6,794-6,806 and 6,816-24 ft. The well had made an estimated 3,000,000 cu. ft. of gas, through 26/64-in. choke, plus some 15 bbl. of salt water an hour, from perforations at the last two levels. Total depth is 10,374 ft.

Standard Oil Co. of Ohio 1 Southern Pine Lumber Co., 3½ miles north of Slocum, in Anderson County, was preparing to squeeze and reperforate in the Woodbine after a 3-hour test at 5,479-90 ft., did not show surface pressure. Recovery from the test was salt water and mud.

In Van Zandt County, 5 miles east of Edom, B. G. Byars 1 Jones, E. C. Bryant Survey, was drilling below 6,947 ft. and looking for the Paluxy. The test is said to be running some 200 ft. high to the discovery of Mount Sylvan field of Smith County, based on top of the Main Street limestone in the 1 Jones, which was placed at 6,110 ft.

An 1,800-ft. test for east central Lamar County, 6 miles southeast of Paris, was reported to be under way by Biggs & Biggs, Tulsa. It will be the 1 L. P. McCuiston Estate, in the Caleb Wood Survey.

EAST TEXAS SUCCESSFUL WILDCAT

Grayson County: Standard Oil Co. of Texas 1 W. F. Covey-Bates, J. B. McAnair Sur., A-763, 2 mi. N Sherman, flowed 89.5 bbl. 36.7°-gravity oil a day, 12/64-in. choke, gas-oil ratio 326:1, oil sand 3,781-89 ft., TD 3,794 ft.

EAST TEXAS WILDCAT FAILURES

Cherokee County: Morris Coats 1 Fred Fowler, Jose Pineda Sur., 4 mi. NW Jacksonville, dry, TD 4,989 ft., Pecan Gap 3,680 ft., Austin 4,590 ft., Woodbine 4,964 ft., by samples.

Wood County: B. B. Orr 1 J. A. Bellomy, J. B. Chireno Sur., 7 mi. SE Winnsboro, dry, TD 5,134 ft., no shows reported, details not available.

TEXAS GULF COAST

New Gas Field For Harris County

HOUSTON.—A new gas field for Harris County, approximately 2½ miles southeast of production in the North Houston field, has been opened by Union Producing Co. 1 Homer J. Moore. Drilled to a total depth of 8,500 ft., with 7-in. pipe cemented at 7,920 ft., this well was cleaning into pits through perforations at 7,705-10 ft., making gas and wash water. No gage has been made of the flow.

Sunray Oil Corp. 1 George H. Brandt, discovery well for the new Brandt field, 1½ miles northwest of the Weser field, in north corner of Goliad County, has been finaled as a single-completion, with the upper gas-condensate sand not being produced at this time. The oil gage from the lower sand (Luling zone) was 168 bbl. of oil per day through a 9/64-in. choke, tubing pressure 1,920 psi., casing sealed, 31.8°-gravity oil, no water, gas-oil ratio 2,814. Production is through perforations at 7,715½-18½ ft. Top of pay was 7,707 ft., with total depth 8,513 ft. The 5½-in. casing was set at 7,770 ft. The Reklaw zone is perforated at 7,440-55 ft. Drill-stem test of these perforations, open 40 minutes, with 500 ft. water cushion, developed 2,050 psi. working pressure and flowed gas and condensate, recovering 120 ft. of fresh water and 60 ft. of colored condensate. However, these perforations are not being produced, and are shut in, with pressure of 2,575 psi.

Oil production for the Los Indios field of Hidalgo County has been opened by Chicago Corp. 7 W. L. Goldston et al. Drilled to a total depth of 7,258 ft., the well gaged 86 bbl. of 42°-gravity oil per day through a 3/32-in. choke, with 1,100 psi. tubing pressure, casing sealed, gas-oil ratio 400, no water. Production is through perforations at 7,113-22 ft. This well is located in the Santa Anita Grant.

Ohio Oil Co. 1-B Nada unit has opened a new shallow sand to production at Nada field in Colorado County. Total depth is 6,843 ft., with 5½-in. casing cemented at 6,671 ft. On initial gage this well flowed 28 bbl. of condensate daily along with an estimated 1,000,000 cu. ft. of gas through a ¼-in. choke. Production is through perforations at 6,216-20 ft. Regular field sands (McDermott sands just below 6,500 ft.) tested salt water.

George R. Brown and Standard of Texas 1 Earl Hankamer, wildcat on the old Gist prospect in the extreme southwestern corner of Newton County, has indicated oil

production from the lower Frio sands. Total depth is 7,354 ft., and 7-in. casing is cemented at 5,835 ft. A drill-stem test through perforations at 5,743-45 ft. recovered 540 ft. of 30.8°-gravity oil, 60 ft. of oil-cut mud and 30 ft. of sand, when tool was pulled.

Amerada Petroleum Co. 1 Charles G. Hooks, wildcat 6 miles east of Warren townsite and 7 miles northeast of South Hyatt field, in Tyler County, is continuing tests in the Wilcox sands. Total depth is 9,503 ft., and 5½-in. casing is set at 7,800 ft. Top of Wilcox is 7,583 ft. On test through perforations at 7,636-39 ft. it showed oil and salt water. These perforations were squeezed and a new test is being made through perforations at 7,609-20 ft.

There were 30 new locations reported this week with 4 being wildcats, 2 in Chambers and 1 each in Karnes and Liberty counties. One new gas pay for Glendale discovery area in Trinity County was opened and six wildcats were completed dry, two in San Jacinto and one each in Austin, Bee, Karnes and Newton counties.

TEXAS GULF COAST SUCCESSFUL WILDCATS

Trinity County: New gas-condensate pay Glendale discovery area—Magnolia Pet. Co. 3 Bolton, in H. Bond League, TD 10,822 ft., top sand 9,932 ft., perf. 9,932-42 ft., and 9,960-90 ft., IP: 8 bbl. condensate per day and 1,173,000 cu. ft. gas per day, gas-condensate ratio 149,412, TP 1,900 psi., SIP 3,584 psi., gravity 47°, 3 bbl. of water per day.

TEXAS GULF COAST WILDCAT FAILURES

Austin County: Humble 1 C. S. Hillboldt, Orange Hill area, in H. E. F. Frisins Sur., dry, TD 10,007 ft.

Bee County: Rowan & Hope 1 Otto Bengston, in Bengston tract, 1½ mi. NE of Pawnee, in B. G. Ijams Sur., dry, TD 6,505 ft. in Wilcox.

Karnes County: H. R. Smith & W. C. McBride, Inc. and P. R. Rutherford 1 Jake Jarmon, in Carlos Martinez Grant, 6 mi. SW of Kenedy, and 4 mi. NW of Green, dry, TD 8,007 ft.

Newton County: C. C. Smith 1 C. C. Brown and Dewey Godfrey, in J. Terry Sur., dry, TD 9,361 ft.

San Jacinto County: Atlantic Refg. Co. 1 R. L. White, Security area, in Mary Rucker Sur., 4 mi. S of Mercy field, dry, TD 10,506 ft.

Magnolia Pet. Co. 2 W. S. Dixon & Falvey, in Shepherd area, in Solomon Cole 1/3rd League, 1 mi. S of Shepherd townsite, dry, TD 11,517 ft.

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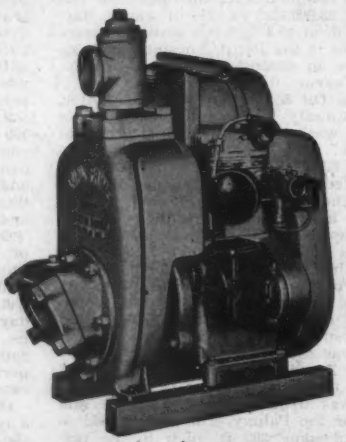

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N. CENTRAL TEXAS

Three Tests Showing For Possible Discoveries

WICHITA FALLS.—Three Haskell County wildcats are showing for possible discoveries. T. D. Humphrey 4 E. H. Barnett et al, 2½ miles north and 6 miles east of Haskell, topped sand with a show of oil at 2,775-78 ft. A drill-stem test at 2,769-78 ft., open 45 minutes, brought gas to the top in 19 minutes. There was no oil flow, but total recovery was 1,055 ft. of oil and 30 ft. of sulfur water. Bottom-hole pressure rose to 1,100 lb. in 20 minues. Operators set 7-in. casing at 2,775 ft. and were drilling plug.

The same company's 1 Gertrude Swan, 3 miles north and 12 miles east of Haskell, made a number of tests in the Ellenburger, topped at 5,532 ft. At 5,590-5,631 ft., open 30 minutes, it recovered 35 ft. of mud, with no shows. At 5,630-70 ft. the recovery was 190 ft. of mud, and 60 ft. of salt water. Previous tests higher in the hole showed gas. At 5,269-73 ft., there was a good blow of gas, and recovery was 15 ft. of free oil, and 25 ft. of mud. At 5,369-79 ft., the recovery was 400 ft. of salt water and a rainbow show of oil.

McCarthy Oil & Gas Co. 2 Hendricks Estate, 3½ miles west of the southeastern corner of Haskell County, topped the Ellenburger at 5,225 ft. and had total depth at 5,320 ft. A drill-stem test at 5,304-20 ft., open 1 hour, recovered 160 ft. of slightly oil and gas-cut mud, plus 200 ft. of salt water. Operators were to plug back to shut off the water.

Fain-McGaha 1-A Amos & Andy, Clay County wildcat 3 miles west and 2 miles north of Joy, topped sand with a show of oil at 3,765 ft. Cores at 3,770-80 ft. recovered 5 ft. of shaly sand and 5 ft. of sand with oil shows. Coring on down, at 3,780-94 ft., the recovery was 14 ft. of oil-bearing sand. At 3,794-3,812 ft., total depth, the recovery was 5 ft. of sand showing oil, 5 ft. of dry sand and 8 ft. of shale. A drill-stem test at 3,765-80 ft., open 45 minutes, recovered 250 ft. of oil and 60 ft. of heavily oil-cut mud. Bottom-hole pressure was 1,575 ft. Operators set casing at 3,755 ft. and were waiting on cement.

In Cooke County, 1 mile west and 1½ miles south of Gainesville, P. G. Lake 2 Pace Brothers had sand with a show of oil at 2,675-82 ft. Cores between 2,682-87 ft. recovered 5 ft. of sand with oil shows, but a drill-stem test at 2,676-87 ft., open 20 minutes, recovered only 25 ft. of slightly oil-cut mud. Cores from 2,750-56 ft. recovered 6 ft. of lime and shale. Top on the Ellenburger was 2,820 ft., and a test at 2,823-66 ft., open 30 minutes, recovered 45 ft. of drilling mud very slightly oil stained. Further tests at 2,875-2,915 ft., open 1 hour, recovered 25 ft. of oil and gas-cut mud. Stuck drill pipe prevented additional tests, and operators were fishing.

Warren Petroleum Corp.'s Jack County wildcat, the 3 S & W Jacksborel, drilled limestone with a slight show of oil at 5,754-64 ft. A test between 5,725-64 ft. re-

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covered 2 bbl. of drilling mud, when the packer failed after 25 minutes. A 1-hour test at 5,721-61 ft. recovered 1½ bbl. of gas-cut mud, and at 5,761-71 ft., open 1 hour, the recovery was 20 ft. of slightly gas-cut mud. Testing continued between 5,795-5,805 ft.

NORTH CENTRAL TEXAS WILDCAT FAILURES

Archer County: M. W. Blair 1 J. J. Perkins, W. E. Probest Sur., A-338, NE Megargle, dry, TD 1,564 ft. in shale, Gunsight 1,452-54 ft., sand with show of oil 1,470 ft.

J. G. Fowler 1 Cora M. Hull, Jose Ostane Sur, A-333, 2 mi. NW Archer City, dry, TD 2,231 ft. in shale, no shows.

Young County: H. W. Snowden Oil & Gas Co. 2 Burch Estate, Sec. 406, TE&L Sur., 5 mi. NW Graham, dry, TD 3,849 ft., sand with show of oil 3,230-45 and 3,823-49 ft., casing collapsed 2,400 ft., estimated 6 bbl. oil and 27 bbl. water a day.

WEST CENTRAL TEXAS WILDCAT

Brown County: W. W. Connell, Inc. 1 O. L. Pierce, Osborne Dalton Sur., 10 mi. NE Brownwood, dry, TD 2,621 ft., sand with show of gas 2,190-2,205 ft., Ellenburger 2,466 ft.

Fisher County: Newmount Oil Co. 1 A. W. Lines, Wm. H. Davis Sur., 4 mi. E Eskota, dry, TD 4,656 ft., Dotham 2,705 ft., Noodle Creek 2,800 ft., Flippen 3,010 ft., dry sand 3,946 ft.

Haskell County: Cabot Carbon Co. 1 Carrigan, S. C. Robertson Sur., 9 mi. NE Stamford, dry, TD 3,255 ft., Palo Pinto 3,195 ft.

Stephens County: Algord Oil Co. 1 G. H. Iles, Sec. 6, AB&M Sur., A-2,604, 14 mi. NE Caddo, dry, TD 4,022 ft., limestone with show of gas 3,935-71 ft., sandy limestone with increase in gas 3,978-92 ft., slight show of oil 4,019-21 ft.

Fred M. Manning, Inc. 1 A. D. Mueller, Sec. 25, A. Marshall Sur., 15 mi. SW Breckenridge, dry, TD 3,650 ft., Caddo 3,367 ft.

Throckmorton County: Owenwood Pool 3 Housley & McCord, Sec. 28, Comanche Indian Reserve, 11 mi. SW Throckmorton, dry, TD 4,794 ft., Mississippi 4,704 ft.

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MISSISSIPPI

Massive Sand Tested In Franklin County

JACKSON.—In Franklin County, J. C. Hawkins 1 Lehman, 27-7n-2e, has cored and tested oil in the Massive sand from 10,548-59 ft. On a drill-stem test with packet set at 10,548 ft. testing to 10,559 ft., with ¼-in. top and bottom chokes, showed 6 psi. top-pressure while open 15 minutes. Cores from 10,531-48 ft. recovered shale with the bottom foot being slightly sandy, carrying a show of oil. Cored hole has been reamed to total depth of 10,559 ft. and operators are planning to resume coring.

Gulf Refining Co. is preparing to start a series of tests on its 1 L. L. Majors, wildcat in the Ovett area of Jones County, total depth 13,251 ft., with 5½-in. casing set at 13,157 ft. in salt. Reports indicate several stringers of sand showing oil and condensate have been logged below 12,200 ft. and total depth.

Danciger Oil & Refining Co. 1 J. C. Simmons, 36-1n-12e, in Heidelberg field, Graben area, has cored to total depth of 9,501 ft. and is preparing to set 9¾-in. casing for production tests. A number of shows have been encountered in sidewall cores of sands from 8,400-9,330 ft.

Humble Oil & Refining Co. 1 Board of Supervisors, wildcat in the Mount Olive area, Covington County, is drilling below 8,300 ft. in sandy shale. Ninety feet of mud and 4,800 ft. of salt water were recovered on drill-stem test at 5,449-61 ft. with 3 psi. working pressure.

In the Sandersville area of Jones County, Union Sulphur Co. 1 A. E. Falls Estate, wildcat is waiting on orders. Total depth is approximately 7,300 ft. with pipe set at 5,456 ft. Drill-stem tests at 5,406-18 ft. and 5,412-34 ft. recovered some oil-cut mud with the oil testing 16° gravity. Drilling rig has been released.

In the Brownsville area, Hinds County, Gulf Refining Co. 1 R. W. Trotter, 15-7n-2w, continues to have slight shows of heavy oil in the "Jackson Gas Rock," however drill-stem tests have recovered salt water at three levels. Operators now are drilling ahead below 4,467 ft. in hard sandy limestone.

MISSISSIPPI WILDCAT FAILURE

Sharkey County: Continental Oil Co. 1 USDA-Holly Bluff, 30-11n-5w, dry, TD 4,450 ft.

SOUTH LOUISIANA

Vermilion Parish Wildcat Indicates New Oil Field

NEW ORLEANS.—A new oil field for South Louisiana was indicated by Stanolind Oil & Gas Co. 1 E. M. Watkins, wildcat in 23-13s-1w, 6 miles east of Florence townsite in the East White Lake area, of Vermilion Parish. On a drill-stem test at 9,278-82 ft., the well flowed at the rate of 206 bbl. of oil per day for 13 hours, then went to 90 per cent salt water. Perforations were squeezed and another test was to be made of the same sands. Total

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depth of the test is 12,191 ft., with 7-in. casing set at 10,900 ft., and 5-in. liner down to 11,900 ft. An initial test at 11,310-25 ft. failed.

Superior Oil Co. 1 State-L. L. & E. deep prospective oil pool opener, in the Four Isle Dome area, Terrebonne Parish, is drilling below 14,200 ft. in sandy shale. The 7-in. casing has been set to 14,028 ft. Several shows of oil have been logged below 13,000 ft.

Pan American Production Co. 2 A. Guillory, 34-3s-1w, in Pine Prairie field in Evangeline Parish has been completed in the Wilcox sands. On initial gage this well flowed 239 bbl. of oil and 10 bbl. of water in 24 hours through a 14/64-in. choke. Flowing pressure was 1,000 psi. on the tubing and gas ratio was 3,060:1. Total depth is 10,351 ft., with 5½-in. casing cemented at 10,326 ft. Production is through 14 sets of perforations in levels ranging from 9,650 ft. down to 10,300 ft.

Stanolind Oil & Gas Co. 1-B O. & V. Ardoin unit, Pine Prairie field, Evangeline Parish, 37-3s-1w, is drilling in sand and shale below 9,450 ft. This test is scheduled to test sands in the Wilcox.

Continental Oil Co. 1 W. W. Duson, wildcat test approximately 1½ miles east of Jennings field production in Acadia Parish, 18-9s-12w, is preparing for production test. Total depth is 12,512 ft., with 7-in. oil string cemented to 10,665 ft. Perforations have been made from 10,550-70 ft. and are being squeezed in three stages prior to a production try. Gas sands have been encountered at 10,450-68 ft. and 10,548-62 ft.

The 19 new locations reported this week include two deep tests to be drilled by Shell Oil Co., Inc., in Weeks Island field, Iberia Parish, projected depths being 13,300 ft. and 14,750 ft. Three wildcat starts were reported, one each in Acadia, Plaquemines and St. John the Baptist parishes. Nine oil producers were completed in proven areas. Two wildcat failures were one each in Avoyelles and Beauregard parishes.

SOUTH LOUISIANA WILDCAT FAILURES

Avoyelles Parish: Dan J. Harrison, Jr., 1 Mrs. E. P. Chenevert et al, Ctr SW NE 20-1s-5e, ½ mi. SE of Plaucheveille townsite, 11 mi. E of Eola field, dry, TD 10,005 ft.

Beauregard Parish: H. L. Hunt 1 Long-Bell Pet. Co., Inc., 28-2s-8w, 5½ mi. E of DeRidder townsite, 15 mi. ENE of Neale field, dry, TD 10,515 ft. Sparta sand 7,143 ft., Wilcox 7,987 ft.

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CALIFORNIA

Production Problems Plague Lawndale Field Discovery

LOS ANGELES.—Water trouble continued to plague Seaboard Oil Co. during the past week at its deep-zone discovery in Lawndale field of Los Angeles County, the 1 Johnson, 17-3s-14w. Latest production gages available indicated that the well was flowing at the rate of 200 bbl. of net oil and 2,500,000 cu. ft. of gas daily under the extreme restrictions of an 11/64-in. choke. Water cut was estimated at 43 per cent.

The heavy cut has been persistent since completion of the well more than a week ago despite many remedial measures taken by the company. It apparently has no hindering effect on the yield of oil and gas, however, as both the productive rate and the pressures have continued unusually high. Casing pressure was gaged at 2,300 psi. during the latest production test, and tubing pressures ranged between 1,850 and 1,875 psi.

Seaboard undoubtedly has uncovered something of considerable importance in the deeper zones at Lawndale, but full potentialities of the discovery cannot be realized until the water problem is solved. The company already has rig up for a second well which may shed some light on the source of the water.

Stuck drill pipe last week threatened Standard Oil Co. of California with a second lengthy delay at its deep wildcat test in the Middle Dome district of Kettleman Hills, the 73-30V, 30-23s-19e. The pipe became stuck at a depth of 10,422 ft., but crews succeeded in loosening it after approximately 30 hours and reaming is now in progress to put the hole in shape for resumption of drilling. The 73-30V originally was drilled to a depth of 12,389 ft. early in the year and was halted at this depth by stuck drill pipe. The bit was in pay sand at this depth, however, and the well flowed substantial quanties of oil through the drill pipe, indicating an important new pay zone discovery for the Middle Dome which has produced no oil at all for several years. After repeated attempts to free the pipe failed, Standard elected to plug back and sidetrack in an effort to complete the well in the new pay zone. This redrilling was in progress when the second fishing job occurred.

Honolulu Oil Corp. is installing pump at its prospective oil discovery between Huntington Beach and Newport Beach, the 1 Lamb, 6-6s-10w. On a formation test, this well flowed an estimated 15-25 bbl. of oil an hour, but flow failed to endure and it will be pumped in an effort to restore the production. Total depth is 5,986 ft. and 7-in. casing has been cemented to 5,970 ft. The 1 Lamb is located approximately 1 mile northwest of the Anaheim Sugar area of West Newport field, and will be the northernmost producer in the area if successfully completed. The newly discovered area will probably be considered a new fault block area of West Newport field.

CALIFORNIA SUCCESSFUL WILDCAT

Los Angeles County, Lawndale area: Seaboard Oil Co. 1 Johnson, 17-3s-14w.

flowed 598 bbl. 15.0°-gravity oil per day through 14/64-in. choke, 2,000,000 cu. ft. gas, 2½-in. tubing 7,893 ft., TD 8,026 ft.

CALIFORNIA WILDCAT FAILURES

Kern County, McFarland area: Universal Consolidated Oil Co. 1 Marquis, 19-26s-27e, dry, elev. 740 ft., top weathered granite 5,250 ft., hard granite 5,261 ft., TD 5,261 ft.

Mount Poso area: Gene Reid Exploration Co. 1 K & M, 7-27s-29e, dry, elev. 1,165 ft., top granite 1,160 ft., TD 1,204 ft.

Race Track area: General Petroleum Corp. 32-2 Glazier, 2-30s-29e, dry, elev. 729 ft., Santa Margarita 1,133 ft., Round Mountain silt 2,755 ft., Olcese 3,773 ft., Pyramid Hills 4,968 ft., Vedder 5,110 ft., Walker 5,380 ft., Schist 5,587 ft., TD 5,809 ft.

Sand Hills area: Western Gulf Oil Co. 1 S. P., 25-12n-20w, dry, elev. 440 ft., Santa Margarita 14,420 ft., TD 15,092 ft.

Monterey County, Oasis area: The Texas Co. 2 Currell, 4-21s-8e, dry in gray sand, elev. 541 ft., TD 2,424 ft.

San Ardo area: Jergins Oil Co. 23-35 San Ardo, 35-22s-10e, dry, elev. 550 ft., TD 2,567 ft.

OHIO, KENTUCKY

Muskingum County Gets Large Gas Well

COLUMBUS.—Salt Creek Development Co. 6 U. S. A. Section 15, Salt Creek Township, Muskingum County, was finished in the Clinton as a large gas well. Sand, found at 4,213-28 ft., gaged 3,108,000 cu. ft. natural with rock pressure of 1,125 lb.

The closely watched wildcat drilled by Republic Steel Co. on its own property in Section 19, Perry Township, Stark County, was drilled in with two pays. The Parker Shell at 4,063-4,100 ft. gaged 393,000 cu. ft. and the Red Clinton at 4,140-73, an additional 331,000 cu. ft. The well was shot and shut in casing 2 hours later at 479,000 cu. ft.

The Ohio Fuel Gas Co. 1 J. G. Strine, Section 19, Congress Township, Wayne County, found an unusually thick Newburg sand at 2,663-2,760 ft. with a natural volume of 206,000 cu. ft. The well will be utilized for some time and then acidized.

Zanesville Tool Co. brought in a fair Medina well on 2 Dell Rambo, Section 26, York Township, Morgan County. Sand at 3,962-74 ft. showed a gage of 500,000 cu. ft. natural.

Perry County again leads in new locations reported with 7 out of a total of 25. Bearfield and Madison townships are showing the most activity. Stark County reports five locations, and Ashland and Meigs three each. Twenty-five wells were completed with Stewart leading with six and followed by Cambridge with five.

SUCCESSFUL OHIO WILDCAT

Stark County, Perry Township: Republic Steel Corp. 1 fee, Sec. 19, Shell 4,063-4,100 ft., Clinton 4,120-85 ft., 497,000 cu. ft., TD 4,207 ft.

EASTERN KENTUCKY ACTIVITIES

ASHLAND.—In the past week, Kentucky-West Virginia Gas Co. completed Well No. 858, W. R. Hall, Sr., property in Floyd County for the only completion. The well was noted at 3,505 ft., and produced 146,000 cu. ft. of gas in shale after shot.

Well No. 5772, James M. Billiter, Pike County, was changed to Well No. 883.

New locations were noted on Well No. 5770, Henderson Hall, Floyd County, and J. S. Franklin, Well No. 5773, Knott County.

WESTERN KENTUCKY

OWENSBORO.—The new Slaughters Pool in Webster County is the hottest thing in Western Kentucky, with 5 wells producing.

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2 dry holes, and 7 drilling. Production is coming from the Tar Springs sand at around 2,500-2,600 ft. The first three wells completed are reported to have averaged 836 bbl. daily per well over a 10-day period, oil 39.6° gravity, gas-oil ratio around 3,000 cu. ft. Early construction of a gasoline plant is planned according to unconfirmed reports.

INDIANA

EVANSVILLE—Two producers and the same number of dry holes marked this week's activity in the new Evansville pool. Calvert-Willis et al 4 Egli, NE NW SW 2-6s-11w and same operators' 4 Roder, SW SE NW 2-6s-11w, each made 15 bbl. pumpers. Illinois Mid-Continent et al 1 Osborn, SW NE SE 3-6s-11w, and Diamond Exploration 1 Nelson, NE NE NE 11-6s-11w were both dry. Eight other wells are drilling.

SOUTHWEST TEXAS

New Field Is Seen For Starr County

CORPUS CHRISTI.—A new oil field for Starr County, 3 miles north of La Reforma field and 2½ miles southeast of the deep production at Kelsey field, has been opened by Jay Simmons 1 First National Bank of Mission in the "San Jose" Grant. On potential test this well gaged 130 bbl. of 41.3°-gravity oil per day on the pump, with no water in the flow. It is completed through perforations at 6,112-17 ft. in the upper sand. Top of upper pay was 6,110 ft. and total depth is 7,500 ft. with 5½-in. casing set to 6,505 ft. for the completion. The lower sand was perforated at 6,421-27 ft. and operator attempted to dual complete this well, but the lower sand developed a high gas-oil ratio, which could not be cut down; the upper sand failed to flow, hence the single-sand completion on the pump. Simmons has started his 2 First National Bank of Mission, 933 ft. south of the 1 discovery well.

Magnolia Petroleum Co. 1-A Drought, wildcat test in Northwest Duval County, approximately 1 mile northwest of the Charamousca field, flowed 1,365,000 cu. ft. of gas per day through ¼-in. chokes top and bottom on a 30-minute drill-stem test through perforations at 6,545 ft., with 1,200 psi. working pressure, and made a spray of condensate, no gage on condensate. Operators have made additional perforations at 6,550-65 ft. and continue to test for a condensate completion. Total depth is 8,504 ft. This well is located in the J. L. Saens Survey 154.

Two miles west of Seeligson field, Magnolia 103 A. A. Seeligson, new oil field discovery in Jim Wells County, on potential gage flowed 144½ bbl. of 42.5°-gravity oil per day through a ⅛-in. choke, with 1,220 psi. tubing pressure, casing sealed. Gas-oil ratio 785. Production is through perforations at 5,857-62 ft. Total depth is 6,010 ft., and 7-in. casing is set to 5,907 ft. for the completion. Drill-stem tests at 4,408-14 ft. and 5,375-82 ft. showed good for gas-condensate production. Located in John H. Houghton Survey 296, approximately 1½ miles southeast of the old Premont field, and 1½ miles northwest of the new South Haldeman field.

Santa Clara Oil Co. and John F. Camp & Sons 4-C Welder, southwest outpost test in the new Squire field of northeastern Duval County, has discovered two new oil pay zones for the field, both below the previous pay zones, and the upper sand being in the Pettus zone, and the lower either in the second Pettus or Yegua zone. Drill-stem test at 3,751-54 ft., open 10 minutes, recovered 40 ft. of gas-cut mud with some oil. Drill-stem test at 3,755-60 ft., open 10 minutes, recovered 30 ft. of oil-cut mud. Drill-stem test in the lower sand at 3,826-30 ft., recovered 50 ft. of oil-cut mud and several gallons of free oil. Test at 3,835-41 ft. recovered 60 ft. of oily mud. Operators will core ahead and continue testing this sand. This well is located in the M. G. Nunez Survey 4, 13 miles northwest of San Diego.

There were 38 new locations reported this week with 13 being wildcats, 4 in Duval and 2 each in Starr and Webb counties, and 1 each in Bexar, Dimmit, Gillespie, Jim Hogg and Uvalde counties. Starr County has two discoveries, one oil and one gas, while Kleberg and Hidalgo counties received one new pay each. Six wildcats were completed dry, 2 in Atascosa and 1 in Dimmit, Jom Hogg, Kendall and Travis counties.

SOUTHWEST TEXAS SUCCESSFUL WILDCATS

Hidalgo County: Oil discovery well in Los Indios pool—The Chicago Corp. 7 W. L. Goldston et al, in Santa Anita Grant, TD 7,258 ft., perf. 7,113-22 ft., IP: 86 bbl. per day through 3/32-in. choke, gas-oil ratio 400, TP 1,100 psi., casing sealed, gravity 42°, no water.

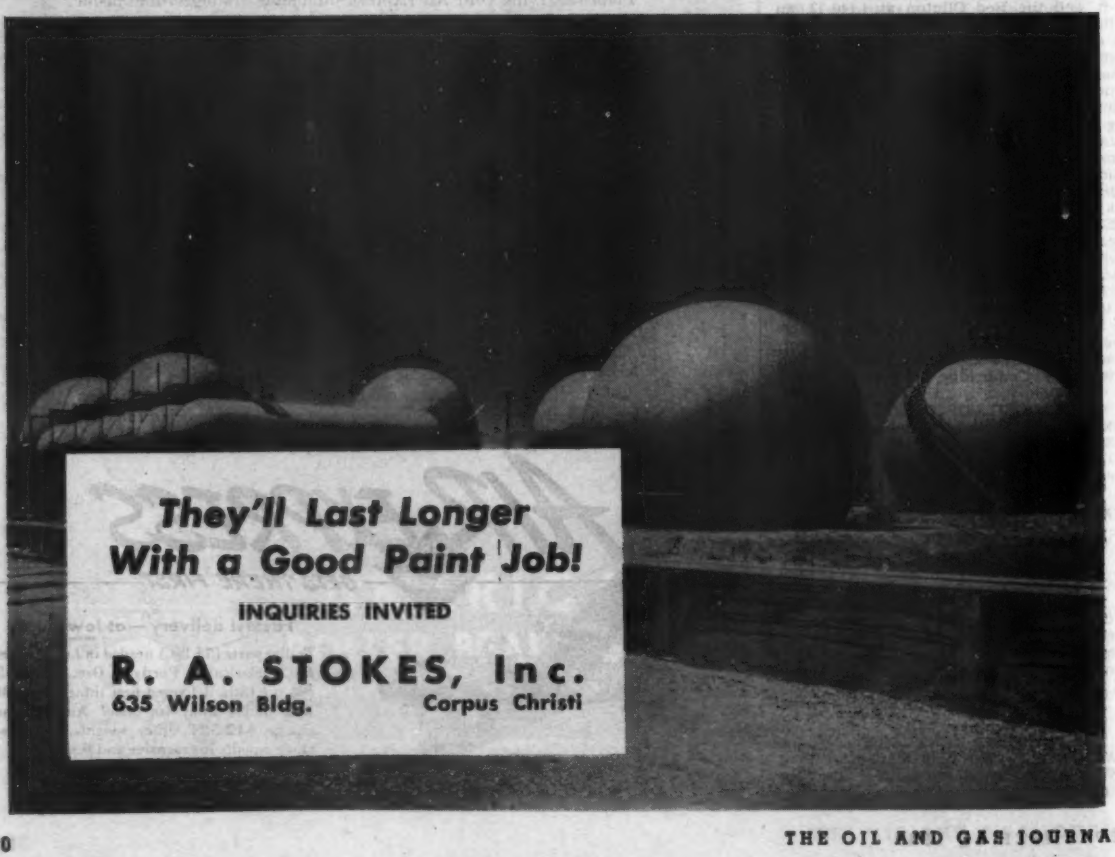
Kleberg County: New oil pay Borregas pool—Humble 9 King Ranch-Borregas, in Santa Gertrudis Grant, TD 9,985 ft., perf. 6,094-99 ft., IP: 168 bbl. oil per day through ⅛-in. choke, gas-oil ratio 912, TP 1,125 psi., casing sealed, gravity 38°, no water.

Starr County: New oil discovery—Jay Simmons et al 1 First National Bank of Mission, in San Jose Grant, 5 mi. NE of Delmita, 2½ mi. SE of Kelsey-Deep field and 3 mi. N of La Reforma field, top pay 6,110 ft., TD 7,500 ft., perf. 6,112-17 ft., IP: 130 bbl. oil per day on pump, gravity 41.3°, no water.

New gas discovery—Selby-Walker Corp. and C. G. Glasscock 1 M. M. Garcia, in Block 3, Survey 913, 12 mi. NE of Rio Grande City, just east of Boyle field, top pay 3,409 ft., TD 4,108 ft., perf. 3,410-20 ft., IP: 3,000,000 cu. ft. gas per day on open flow (dry gas), shut-in pressure 1,600 psi.

SOUTHWEST TEXAS WILDCAT FAILURES

Atascosa County: Frank Frohnhoefer 1 E. C. Rogers Est., in Rafael Herrera



Sur. 44, 5 mi. NW of Poteet, dry, TD 2,607 ft. in upper Taylor.

Pegg Bros. 1 Oscar Brooks, in F. de la Garza Sur. 46, 9 mi. W of Poteet, dry, TD 2,441 ft.

Dimmit County: The Texas Co. 1 E. T. Standifer, in J. Poitevent Sur. 35, 7 mi. E of Big Wells, in Las Vegas area, dry, TD 8,411 ft. in lime.

Jim Hogg County: V. L. Blanchard 1 Downs Royalty Corp. in El Javali Grant, 8 mi. SW of Cuevitas, 3½ mi. NW of Guerra field, dry, TD 8,540 ft.

Kendall County: B. L. Raborn, Jr., 1 Olga Hohenberger, in H&GN RR Sur. 950, 10 mi S. of Fredericksburg, dry, TD 720 ft.

Travis County: E. R. Marts 1 Henry Lind, in Henry Martin Sur., dry, TD 1,935 ft., top Edwards lime 1,930 ft.

CANADIAN FIELDS

Leduc Field Extended 1½ Miles to West

CHATHAM.—In Leduc field, Globe-Leduc West 2, LSD 9, 34-50-26w4, finished at 5,284 ft. as the first independent producer, came in after swabbing to the 2,500-ft. level. For 20 minutes the flow was directed to the flare line, and then switched to the separator with flush yield of 158 bbl. in 1 hour. It was then restricted to 21/64-in. choke, making 27 bbl. an hour. On a later half-hour open flush run it made 75.2 bbl. and on restricted flow is making between 500 and 600 bbl. a day, apparently one of the largest producers yet brought in. The completion extends the producing area 1½ miles west. Globe-Leduc West 1, LSD 6, 19-50-26w4, to the west of the field, is below 4,733 ft. after coring in the first zone. Globe-Leduc West 3, LSD 10, 34-50-26w4, offsetting No. 2 producer to the west, is rigging, and the company is planning six additional wells on the same quarter-section.

Imperial 8, LSD 7, 26-50-26w4, has been completed as the company's eighth successive producer, flowing 110 bbl. an hour in a drill-stem test at 5,310-20 ft. On restricted flow, it is expected to bring total field production to better than 1,100 bbl. a day. Imperial has three other wells drilling close to the producing horizon and one rigging.

Leduc Consolidated 1, LSD 10, 23-50-26w4, after shutting in a large gas production from the upper formations, is nearing the third zone below 5,348 ft. Leduc Consolidated 2, LSD 7, 23-50-26w4, got the second zone at 4,971 ft. and is deepening to test the third. Leduc Consolidated 3, LSD 15, same section, is below 4,990 ft.

Homestead-Yaremko 1, LSD 7, 19-50-25w4, to the east of the field, is deepening below 5,357 ft. after a rise of water in the second zone. New Ranchmen's-Community 1, LSD 11, 7-49-24w4, outpost test to the southeast, is below 5,357 ft.

Okalta-Leduc 1, LSD 13, 7-50-25w4, outpost test to the east, was dry at 6,110 ft. B. A. Pyrcz 1 deep test, LSD 12, 25-50-26w4, is below 6,085 ft.

Millet.—Southwest of the field, Millet-Leduc 16-6, LSD 16, 6-48-24w4, got the first Leduc zone high, at 4,640 ft., showing oil stains in a tight formation with the electric log indicating porosity. Drill-stem test was unsuccessful owing to packer trouble, and the hole is deepening to the more productive second zone, expected around 5,150 ft.

Wizard Lake.—McColl-Frontenac Wizard Lake 14-14, LSD 14, 14-48-27w4, about 12 miles south and west of the Leduc producers, was dry at 6,166 ft. This is the last of three exploratory tests drilled by McColl-Frontenac in areas south of Leduc field, toward Wetaskiwin. A new wildcat test, Spotted Creek 8-24, LSD 8, 24-42-24w4, has been spudded still farther south, and east of Ponoka.

Turner Valley.—Home-Millarville 26, LSD

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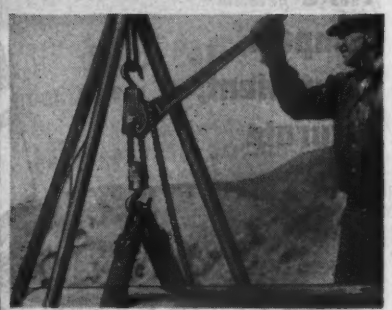

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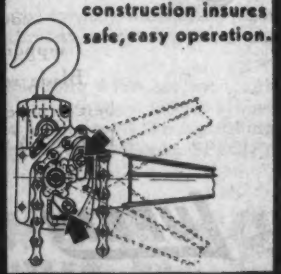

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15, 18-21-3w5, outpost test in the north extension area, with Madison at 8,541-8,971 ft., has increased to 12 bbl. an hour in the lower zone, and is continuing acidizing and testing. Four other Home wells in northwest Turner Valley are drilling.

Jumping Pound.—Shell Exploration 5-7-1, LSD 5, 7-25-4w5, deepest active test in Alberta, is deepening below 13,290 ft. after a drill-stem test in the Devonian limestone showed 310-ft. rise of fluid in 10 minutes with no oil showing.

Bruderheim.—North of Edmonton, Shunda B-1, LSD 5, 20-55-20w4, got the Devonian limestone around 3,222 ft. and is coring below 3,571 ft. to test oil showings.

Pouce Coupe.—In the Pouce Coupe area of northwestern Alberta and northeastern British Columbia, an oil showing has been struck at 800 ft. close to the town of Pouce Coupe. The well was drilled for a town water supply, apparently on the British Columbia side of the interprovincial boundary, and is reported making 15 bbl. a day with strong gas pressure. The location is in a general area in the northern foothills, tested by Imperial Oil and other companies between 1921 and 1944. Northwest Co. (Imperial) 1, LSD 15, 23-80-13w6, abandoned as an oil prospect at 3,057 ft., encountered a strong gas flow, estimated 10,000,000 cu. ft. with 500 lb. closed-in pressure. Bonanza Royalties 1, LSD 16, 23-80-13w6, finished at 2,173 ft., had around 5,000,000 cu. ft. gas and Guardian 1, LSD 7, 7-80-12w6, stopped drilling at 6,900 ft. after encountering numerous oil and gas shows.

Ontario.—A test for natural gas on the Edward Corrie farm in Bertie Township, Welland County, east of Port Colborne, has encountered a small commercial oil production, around 5 bbl. a day. The test, drilled in the old Niagara gas field, encountered oil below 1,500 ft. Production is being shipped to the British-American refinery at Clarkson.

Nova Scotia.—After more than 2 years of drilling for oil in Nova Scotia, Sun Oil Co. has discontinued operations, and is shipping its drilling equipment to the United States. Operations were carried on at Nappan, near Amherst. The first test was abandoned owing to drilling difficulties around 6,000 ft. and a second hole, carried to 11,504 ft., failed to secure production. A number of previous efforts to develop oil in Novia Scotia, particularly on the western shore of Cape Breton Island, were unsuccessful.

PERMIAN BASIN

Anderson Test Still in Pay at 8,340 Ft.

MIDLAND.—Phillips Petroleum Co. and The Texas Co. 1 McEntire, Ector County Ellenburger strike, 2 miles southeast of Andector field, was still in the pay at 8,430 ft. A 76-minute drill-stem test between 8,340-8,430 ft. brought gas to the surface in 5 minutes, oil at the end of 16 minutes, and then flowed 115 bbl. of oil to tanks in 1 hour. Final recovery on the test was not reported. Operators were to run another test at 8,430-80 ft., then continue testing at 50-ft. intervals. Location of the 1 McEntire is about 2 miles southeast of the nearest Ellenburger well in Andector field, but some operators consider it as a separate structure, since it is separated from the field by a dry hole.

Phillips 1-P TXL, Devonian extension on the north side of TXL field, flowed 232 bbl. of oil, with no water, through ½-in. choke, from the Devonian, and was shut in for additional storage. Total depth was 8,345 ft., plugged back to 7,960 ft., and with packer set at 7,854 ft. Location is in SW SE Section 29, Block 45, T&P Survey, and slightly more than 1 mile northwest of the nearest Devonian producer, Continental Oil Co. 2-B TXL, and the same distance northeast of Shell Oil Co., Inc.,

1 Cochran, a Devonian producer separated from TXL field by a dry hole.

At the south end of Goldsmith field, 6½ miles south of previous Clear Fork production, Gulf Oil Corp. 437 Goldsmith, Section 28, Block 44, T&P Survey, flowed 66 bbl. of oil in 1 hour on a drill-stem test in the Clearfork section at 5,598 ft. When the tool was opened, gas came to the surface in 4 minutes, oil in 13 minutes, which was turned into the pits for 22 minutes to clean. At that time it was turned into tanks for the 1-hour flow. Gas-oil ratio was said to be 680:1. Operators were to deepen before making further tests.

Previously, the 437 Goldsmith had recovered 840 ft. of oil and gas-cut drilling mud in a test from 5,450-5,567 ft.

Sterling County's discovery, Plymouth Oil Co. 1 Mrs. Georgia Frost, swabbed 110 bbl. of oil and 112 bbl. of water in 24 hours, early this week, and was to continue testing the Ellenburger. Present perforations are between 8,358-78 ft. Operators were to squeeze more cement through the pipe, above the zone being tested, in an effort to shut off the water.

In the panhandle of northwestern Crockett County, Byrd-Frost, Inc., and Gulf 1 Mayberry-Tippet, which blew out from pay section at 6,309-99 ft., following a drill-stem test of the Simpson formation at 6,870-7,001 ft., total depth, was to pump in mud, in an effort to kill the well. When the gas flow is killed, operators planned to drill ahead to the Ellenburger.

Completion potential was reported for Honolulu Oil Co. 1 White & Shelton, Gaines County, discovery 12 miles west of Seminole, in Section 18, Block 44, T&P Survey, as 161 bbl. of fluid a day, on the pump. Of that amount, 156 bbl. was 31.5°-gravity oil. Total depth was 7,003 ft., plugged back to 6,959 ft. in the Clear Fork.

In south-central Andrews County, Stanolind Oil & Gas Co. 1-AC University extended San Andres production 1½ miles south of Fuhrman-Mascho field. On a 24-hour pumping test, the well made a little better than 68 bbl. of fluid, of which 93 per cent was oil, and the remainder sediment and water. Pay section from 4,190-4,447 ft. was acidized. Total depth was 7,000 ft., in the Clear Fork, plugged back to 4,467 ft.

WEST TEXAS SUCCESSFUL WILDCAT

Crockett County: Stanolind Oil & Gas Co. 1-GG University, Sec. 12, Blk. 39, University Lands, 12¼ mi. SE Barnhart, pumped 25 bbl. 37.5°-gravity oil a day, Ellenburger pay 8,298 ft., TD 8,384 ft., PB 8,377 ft.

WEST TEXAS WILDCAT FAILURES

Andrews County: McAlester Fuel Co. 1 M. M. Fisher, Sec. 4, Blk. A-36, PSL Sur., 1 mi. N Shafter Lake field, dry, TD 7,365 ft., Yates 2,860 ft., Glorietta 5,740 ft., Clear Fork 6,167 ft., Tubb 6,695 ft.

Dawson County: R. G. Clay 1 O. W. Jones, Sec. 26, Blk. 35, T&P Sur., 4½ mi. SE Lamesa, dry, TD 4,360 ft., San Andres 4,360 ft.

Yoakum County: The Texas Co. 1 Roy Fitzgerald, Sec. 440, Blk. D, J. H. Gibson Sur., 2 mi. E and 1 mi. S Plains, dry, TD 5,524 ft.

SOUTHEASTERN NEW MEXICO

HOBBS.—Amerada Petroleum Corp. announced location for a deep test in the southwest part of the Monument area of Lea County. It will be the 8 H. W. Andrews, in NW NW 12-20s-36e, and 1 mile southwest of the same company's 5 Phillips in 1-20s-36e, last reported drilling ahead below 7,852 ft.

In west-central Lea County, Cole-Darden Oil Co. 1 Phillips-State, 30-17s-34e, was to reacidize with 5,000 gal. in the San Andres from 4,609-4,760 ft. Previous treatments were with 500 gal. of mud acid and 2,000 gal. of regular acid, after which it flowed 10 bbl. of oil an hour. A drill-stem test of the above depth, open 90 minutes, recovered 480 ft. of heavily gas-cut mud, and 300 ft. of oil and gas-cut mud. When shut in it built up a pressure of 750 lb. in 9 minutes.

Continental Oil Co. 6-B-23 Skaggs, 23-20-27e, in the Cass field area, recovered sulfur water with no oil or gas shows, on a 1-hour drill-stem test of the Devonian at 8,155-8,354 ft., total depth, and operators planned to plug back to test the upper Strawn and Drinkard zones.

Between the Drinkard and Skaggs-Cass producing areas, Stanolind Oil & Gas Co. 1 Southland Royalty Co., 9-21s-37e, had perforated casing at 6,555-6,610 and 6,640-75 ft. and was to run tubing to test. Total depth is 6,684 ft.

SOUTHEASTERN NEW MEXICO SUCCESSFUL WILDCAT

Eddy County: Extension to Grayburg-Jackson area—Grayburg Oil Co. 13-B Keeley, NE SW NE 26-17s-29e, flowed 236 bbl. oil a day, ¾-in. choke, San Andres 2,612 ft., top pay 2,835 ft., TD 5,076 ft., PB 3,050 ft., elev. 3,588 ft.

MICHIGAN

Allegan County Wildcat Gets 66-Bbl. Initial

SAGINAW.—Ford Oil Co. 1 Bloom, classed as a wildcat in Section 34 of Salem Township, Allegan County, produced initially after acidizing at 66 bbl. a day, with salt water, from the Traverse limestone at 1,680 ft. as Michigan field operations in the past week resulted in 14 completions.

The completions included four other oil wells, one for 780 bbl. initially in Newaygo County's Kimball Lake field, another for 360 bbl. pinched in Claybanks field of Oceana County, smaller producers in Midland and Bay counties. Initial potential of

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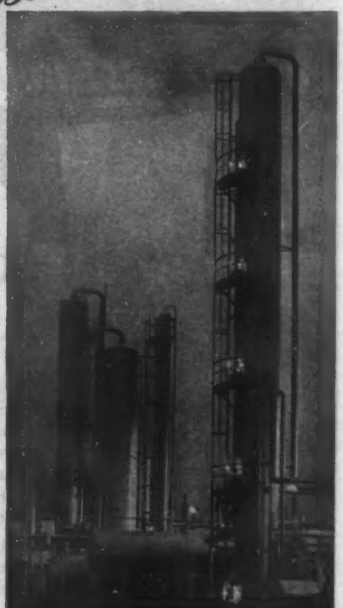

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the five producers was 1,300 bbl. a day.

Four more Clare County gas producers were on the list, along with five dry holes, four of which were wildcats.

Only eight new locations were listed, four of them in Newaygo County, one each in Kalamazoo, Kent, Allegan, and Livingston counties.

MICHIGAN WILDCAT PRODUCER

Allegan County, Salem Township: Ford Oil Co. 1 Orville Bloom, SE NE NE 34-4n-13w, pumped 60 bbl. and salt water, acidized; TD 1,680 ft. in Traverse limestone.

MICHIGAN WILDCAT FAILURES

Bay County, Garfield Township: Chapman Oil Co. 1 J. F. Lambert, SE NW SE 26-16n-3e, dry in Dundee, TD 3,408 ft.

Oceana County, Leavitt Township: Gordon Oil Co. 1 Osborn & Hill, SW SE NE 26-15n-15w, dry in Detroit River, TD 2,738 ft.

Oscoda County, Mentor Township: J. O. Mutch 1 Neil W. Oakes et al, NW SW NW 30-26n-3e, dry in Dundee, TD 3,275 ft.

ILLINOIS

White County Has Two Small Pool Prospects

MATTOON.—Ashland Oil & Refining Co. et al 1 Orman, SW NW NW 18-6s-10e, swabbed 70 bbl. of oil in 4 hours after acidizing the McClosky with 4,000 gal. at 3,052-59 ft. Elevation is reported 385 ft.

Gilliam Drilling Co. 1 Hines, NW NW SW 36-5s-10e, after being plugged back to 2,847 ft., from old total depth of 3,167 ft., is being put on pump to test the Benoist sand at 2,812-30 ft.

In the Inman district, Gallatin County, R. B. Martin-Puritan Drilling Co. 1 Straub, NE NE NE 21-8s-9e, potential new pay opener in the Tar Springs sand, bailed 2½ bbl. of oil per hour, then was shot with 40 qt. at 2,191-2,215 ft., and is now cleaning out.

George Wrather 1 Turner, NW NE NW 23-1s-9e, Wayne County, elevation 287 ft., swabbed 100 bbl. of oil in 8 hours after acidizing with 3,000 gal. The well is now being cleaned out and tested after perforating with 24 shots at 3,340-46 ft., total depth 3,375 ft. Tuley-Carter 1 Martin heirs, NW NW NW 4-2s-8e, is cleaning out after a 20-qt. shot in the Aux Vases at 3,186-3,200 ft.

ILLINOIS SUCCESSFUL WILDCATS

Clark County: F. Hessler 1 Buckler, SE SE NW 36-12n-14w, TD 460 ft., Pennsylvania, shot 453-60 ft., pumped 3 bbl.

Van Tarble 1 Tarble Brothers, SW NW SW 1-11n-14w, TD 678 ft., PBTD 390 ft., pumped ½ bbl.

Edwards County: Lynn and Calvert & Willis 1 Messman, NW NW SW 9-2s-14w, TD 3,075 ft., PBTD 2,975 ft., Aux Vases and Benoist, shot 2,959-75 ft., 7 qt. marbles in Aux Vases, pumped 11 bbl.

ILLINOIS WILDCAT FAILURES

Effingham County: Everhart 1 Bryant, NW NE NW 9-6n-7e, dry, TD 2,930 ft.

Eason Oil Co. 1 Niemann, N½ SE NE 35-6n-7e, dry, TD 3,051 ft.

Fayette County: H. Luttrell et al 1 Cole, SE SE SE 27-5n-3e, dry, TD 2,067 ft.

Jefferson County: W. Bell and Ashland 1 Lyton, NW NW SW, dry, TD 3,097 ft.

Macoupin County: Gill 1 O'Neal, SE SW SE 22-11n-8w, dry, TD 602 ft.

Marion County: Gilliam Drilling Co. 1 Frye "A," NE NW SW 2-2n-4e, dry, TD 2,792 ft.

Shelby County: Burke, Ryan & Hayes 1 Morris, NW NE NW 12-9n-3e, dry, TD 1,985 ft.

Wayne County: Texas Co. 1 Scott, NW NW SW 27-1n-5e, dry, TD 3,100 ft.

LA.-ARK.

Madison Parish Test Gets Show of Gas

SHREVEPORT.—Seven miles south of Delhi field in Madison Parish, Murphy and Sun Oil Co. 1 R. F. Marston, 19-16n-10e, reported spotted stains and shows of gas. In coring, a 5-ft. recovery at 4,965-70 ft. was of nonporous sand, with no shows. Five feet recovered at 4,970-75 ft. had 2 ft. of nonporous sand and 3 ft. of sand having gas odor and spotted oil stains. At 4,975-80 ft. there was 1½ ft. of sand with gas odor, good porosity with spotted oil stains, and 3½ ft. of salt-water sand. Operators ran electric log and were waiting on cement.

Other wildcat reports indicated progress in drilling but little change from the previous week. Two miles northeast of the town of Ringgold, Bienville Parish, The Texas Co. 1 W. A. Givens was drilling below 6,799 ft. It had the Massive at 4,545-4,767 ft., Pettit porosity at 5,785-5,804 and 5,846-50 ft., and sample top on the Travis Peak was 6,280-95 ft. Union Producing Co. and Pure Oil Co. 1 Frazier, 14-14n-6w, had made two attempts at drill-stem tests, with the packer failing both times. First test was between 7,989-8,074 ft., and the second at 8,016-74 ft. No recovery was reported. Operators then reamed down to 8,068 ft., and cored red and gray shale to 8,133 ft. Top on the Travis Peak was said to be 7,655 ft.

In Caddo Parish, F. A. Callery 1 Woolworth, 22-12n-15w, was shut down for water at 3,990 ft. Cores at 3,853-57 ft. recovered shale and limestone, with no shows. Sample top on the Paluxy was 2,825 ft. Northwest of Willow Lake field, irregular Section 35-7n-6e, General American Oil Co. 1 Calvert was drilling below 7,828 ft. in shale. It topped the Midway at 7,410 ft., by samples. Two Claiborne Parish tests, Carter Oil Co. 1 Gandy, 28-19n-7w, was drilling below 5,336 ft., and Hassie Hunt 1 James, 10-22n-4n, was drilling in Cotton Valley at 9,060 ft. Skelly Oil Co. 1 Nash, 20-12n-16w, DeSoto Parish, was drilling below 10,797 ft. in black shale. In LaSalle Parish, C. H. Murphy, Jr., 1 Tensas Delta, was drilling below 8,207 ft., and in 15-10n-4e, Placid Oil Co. 126 Louisiana Central Lumber Co. was coring at 6,898 ft.

Arkansas exploration reports included Southern Producing Co. et al 1 Morris (formerly reported as Chicago Corp.) which was drilling below 4,315 ft. in the Cotton Valley formation. Location of the wildcat is 2½ miles northeast of Wilmot, in 31-18s-4n, Ashley County. West of Stephens field, McAlester Fuel Co. 1 Paschall, 9-15s-20w, Columbia County, topped the Cotton Valley at 4,760 ft., and was drilling below 5,824 ft. John A. Kennedy 1 Ward, shallow test in 31-8s-23w, Hempstead County, was drilling below 927 ft. in the Eagle Mills. In Lafayette County, 8-18s-23w, Barnsdall Oil Co. et al 1 Bodcaw was below 7,574 ft. in Cotton Valley. Two miles east of Stephens field, Lee & Burnett 1 E. H. Morgan, 27-15s-19w, Ouachita County, had total depth at 3,142 ft. and was making pumping tests from perforations at 3,068-3,106 ft. No details were available as to what it was pumping.

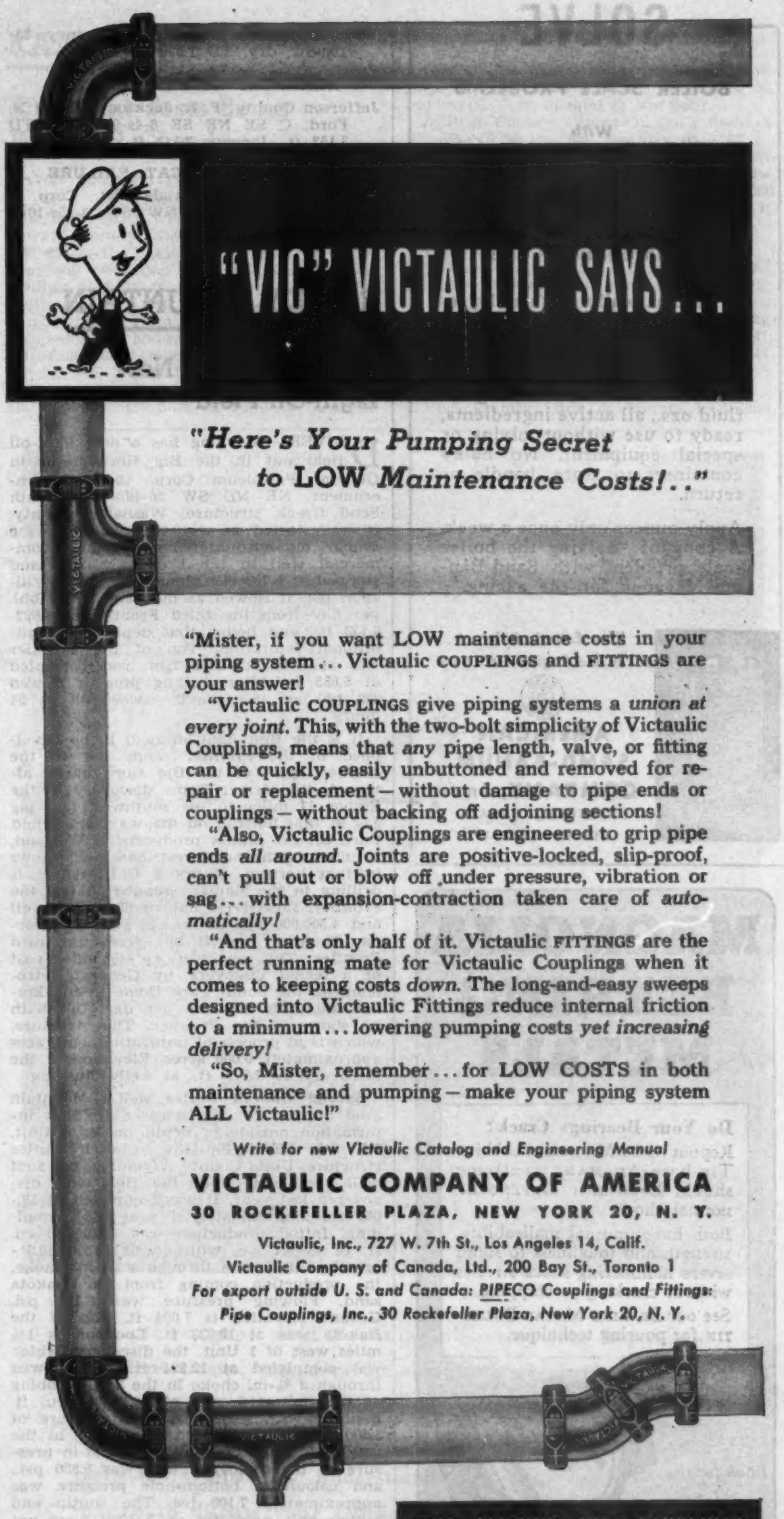
NORTH LOUISIANA WILDCAT FAILURES

Bossier Parish: C. M. Bagley 1 J. L. Bundy, NW NW NE 31-20n-12w, dry, TD 2,506 ft., Midway 630 ft., Annona 1,760-1,886 ft., Tokio 2,310 ft., elev. 227 ft.

Texas Gulf Producing Co. 1 Mooney, 28-19n-11w, dry, TD 3,180 ft., Annona 1,068-1,170 ft., Blossom 1,215 ft., Tokio 1,396 ft., Massive anhydrite 2,407-2,602 ft., elev. 229 ft.

Natchitoches Parish: E. H. Demetrio 5 Prudential Insurance Co., NW NE SE 16-10n-9w, dry, TD 1,622 ft., no details available.

Union Parish: Primos & Sharp 1 Green, 7-21n-1w, dry, TD 2,323 ft.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ARKANSAS WILDCAT FAILURE

Jefferson County: F. R. Jackson 1 David N. Ford, C SE NE SE 6-4s-9w, dry, TD 3,153 ft., Igneous 3,143 ft.

ALABAMA WILDCAT FAILURE

Fayette County: Amerada Pet. Corp. 1 D. H. Wright, C NW SW 8-15s-10w, dry, TD 4,571 ft.

ROCKY MOUNTAIN

Wyoming Gets New Light-Oil Field

DENVER.—Wyoming has a new light-oil field out in the Big Horn basin in General Petroleum Corp. 46-26 Governernment, NE NE SW 26-46n-91w, South Sand Creek structure, Washakie County. It was started as a 10,000-ft. test to the Embar, but encountered shows for a commercial well in the Frontier sands, and stopped at 6,753 ft. to complete. In a drill-stem test it flowed at the rate of 445 bbl. per day from the third Frontier at 6,692-6,738 ft., and below that depth cored additional saturation. Top of the Frontier was at 6,690 ft., and 7-in. was cemented at 6,685 ft. After drilling plug it flowed 832 bbl. of 45.3°-gravity sweet oil in 24 hours.

It is the first light-oil field to be developed in the Frontier sands out in the southern part of the Big Horn basin, although the Neiber Dome discovery in the Embar 11 miles to the southwest had big gas in that horizon on the way down, and Pure Oil Co. Embar producers at Worland, 15 miles to the northwest, had good shows in that horizon. Pure's 5 Unit, which is drilling to the Embar, stopped to test the Frontier, flowed 110 bbl. of 60°-gravity oil and 4,500,000 cu. ft. of gas from the second Frontier, and 41 bbl. from the third Frontier. The new well is 4½ miles east of a recent discovery by General Petroleum on the South Fork Dome in the Embar, pumping 200 bbl. per day, but with no shows in the Frontier. The structure, which is in process of unitization, embraces approximately 9,000 acres. Elevation of the discovery is 7,779 ft. at kelly bushing.

Second Church Buttes well. — Mountain Fuel Supply Co. has released its first information outside of depth on its 3 Unit, NE SW NE 12-16n-113w, Church Buttes structure, Uinta County, Wyoming, the first well completed since the field was discovered last year. It was completed at 13,063 ft., approximately 1 year after spudding. Initial production was 17,400,000 cu. ft. of sweet gas with considerable 48.5°-gravity condensate through a ½-in. choke, the production coming from the Dakota sand. Flowing pressure was 2,151 psi. Ground elevation is 7,094 ft. Top of the Dakota was at 12,933 ft. Location is 1½ miles west of 1 Unit, the discovery, which was completed at 12,894 ft., and flowed through a ⅞-in. choke in the 2½-in. tubing at the indicated rate of 34,385,000 cu. ft. per day with surface flowing pressure of 1,500 psi., and produced condensate at the rate of 215 bbl. per day. The shut-in pressure of the discovery well was 5,550 psi., and calculated bottom-hole pressure was approximately 7,100 psi. The shutin and bottom-hole pressures on 3 Unit were not reported, but the well is said to be as good as the discovery. The unitized area embraces 49,838 acres, but extensive holdings outside the unit are reported held by the operating interests. The 2 Unit, which was drilled concurrently with 3 Unit, is located 4¾ miles to the northeast of the discovery, and is now being completed after overcoming a split in the casing. Present drilling program calls for two more wells, both of which are getting under way.

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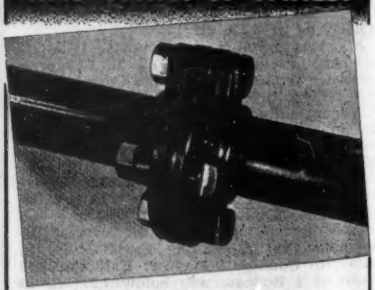

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South Sand Draw.—Sinclair-Wyoming Oil Co. 15 Sand Draw Gas unit, SE SW SE 23-32n-95w, Big Sand Draw field, Fremont County, Wyoming, was completed for 3,600,000 cu. ft. of gas per day through perforations opposite three zones in the Frontier formation after plugging back from a total depth of 6,117 ft. to 4,360 ft. Ground elevation is 6,679 ft. Its location is ½ mile north of a well completed last year by R. S. Shannon's Sand Draw Oil Co. for estimated 20,000,000 cu. ft. of gas per day from the Frontier sands. This well was started as a Tensleep test on what is believed to be a separate structure or an important extension of the field to the north, but stopped after finding gas in the Frontier. Sand Draw Oil Co. has made a location for 1 Government only 125 ft. north of last year's discovery to got to the Tensleep, the original objective. It is 2 miles south of Sinclair-Wyoming 5 Unit which recently was completed in the north field for 3,151 bbl. initial from the Tensleep, and is the most southerly well in the fields.

New operations.—Twenty-eight new operations were reported, of which 4 were in Colorado, all in Rangely field, 15 in Wyoming, and 9 in Montana. These included two wildcats in Wyoming and two in Montana. One of the Wyoming tests is Clark Drilling Co. 1 O'Brien, SE SE SE 24-46n-65w, Fiddler Creek, Weston County. The other is South Sand Draw Oil Co. 1 Government, NE SW NE 26-32n-95w, South Sand Draw, Fremont County, a test to the Tensleep, 125 ft. north of a gas discovery last year in the Frontier. An important outpost is Phillips Petroleum Co.-Morton-Torgeson 1 Wakeman, C NW SE 7-44n-63wm, Much Creek district, Weston County, 1¼ miles north of nearest producer. Montana wildcats are Grant Oil Co. 1 Opland, SE SW SE 10-3n-18e, Six Shooter district, Sweetgrass County, and Bonneville Oil & Gas Exploration Co. 1 Worthington, C SE NE 14-2s-6w, Grantsville district, Toole County.

WILDCAT FAILURES IN COLORADO

Santa Clara, Huerfano County: Rainbow Drilling Co. 2 Capps, NW SE SW 12-28s-65w, TD 850 ft., P. & A. Dakota, 477; Morrison, 845 ft.

Piceance Creek, Rio Blanco County: General Petroleum Corp. 24-12-G, SE SW NW 12-2s-96w, TD 3,698 ft., show of oil in Green River formation at 3,665-80 ft., with 500,000 cu. ft. of gas. P. & A. as noncommercial. Test 2 miles northeast nearest gas well for oil on flanks.

SUCCESSFUL WYOMING WILDCAT COMPLETIONS

South Sand Creek, Washakie County: General Petroleum Corp. 45-26 Government, NE NE SW 26-46n-91w, TD 6,753 ft., top third Frontier 6,690 ft., 7-in. 6,685 ft., ground ele. 4,395 ft., flowed 832 bbl. 45.3°-gravity sweet oil in 24 hours from Frontier.

Seven Mile, Albany County: California Co.-Phillips Petroleum Co. 1 Christiana, NE SE SE 8-17n-77w, TD 6,776 ft., plugged back and completed in Muddy sand, swabbed 195 bbl. in 24 hours. All sands below Muddy carried water. Muddy, 5,820; Dakota, 5,915; Lakota, 5,960; Morrison, 6,008; upper Sundance, 6,555; red beds, 6,775; ele. 8,004 ground.

Church Buttes, Uinta County: Mountain Fuel Supply Co. 3 Unit, NE SW NE 12-16n-113w, TD 13,063 ft., IP 17,400,000 cu. ft. of gas with considerable condensate through ½-in. choke in 24 hours from Dakota, flowing pressure 2,125 psi. Green River, 1,770; Wasatch, 3,120; post-Laramie, 5,250; Adaville, 7,020; Blair, 8,685; Hilliard, 9,410; Frontier, 12,483; Aspen, 12,515; Dakota, 12,933; ele. 7,094 ground.

WYOMING WILDCAT FAILURE

Big Piney, Sublette County: Superior Oil Co. 1 Fear, SE NE NE 15-29n-113w, TD 3,846 ft. P. & A.

KANSAS

Stanolind Tests Being Watched Closely

TWO Stanolind Oil & Gas Co. wildcats were attracting most interest in an otherwise quiet week for exploration. In Seward County, Stanolind 1 Wheatley, NE SW 23-33s-31w, east of the Hugoton field, near the west line of Meade County, was drilling at 6,377 ft., after topping the Mississippian at 5,602 ft. Drill-stem tests at various points from about 4,400 ft. have developed slight shows.

In Comanche County, Stanolind's 1 Winkler, NE NE NW 6-31s-19w, is drilling below 5,575 ft., after topping the Lansing at 4,382 ft., and Mississippian at 5,018 ft. A drill-stem test at 5,029-53 ft., recovered a small amount of gas and gas-cut mud; one at 5,077-5,113 ft., had a good blow and recovered 30 ft. of mud, and one at 5,147-91 ft., recovered 35 ft. of mud in one hour.

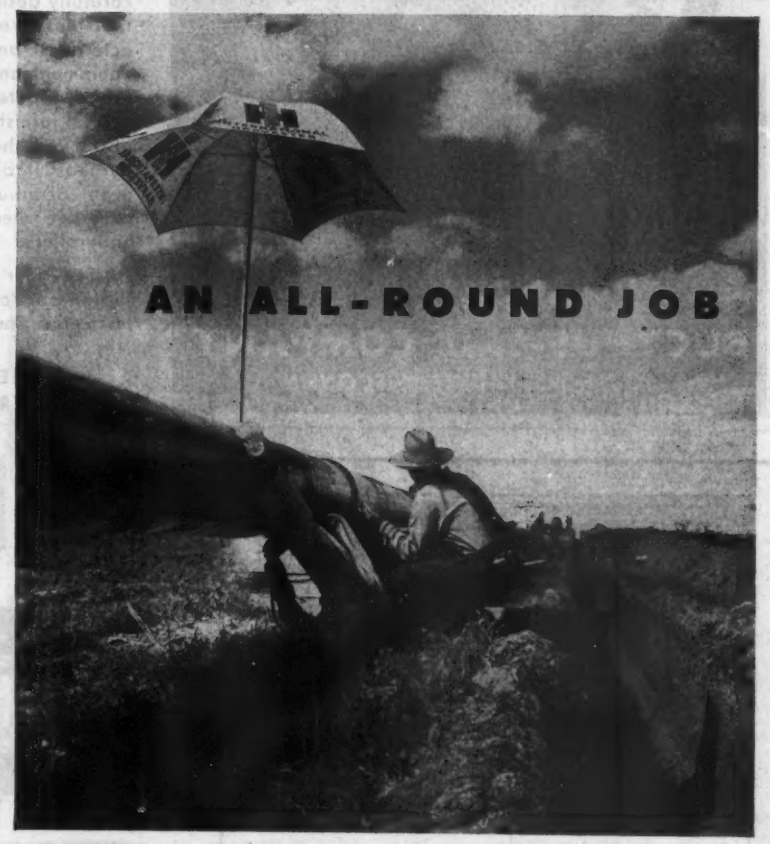
In Rush County, Crown Oil Co. 1 Josefiak, SE SE NE 26-19s-19w, was dry at 4,232 ft., after topping the Arbuckle at 4,180 ft. Bennett et al 1 DeWald, SW SW NE 2-15s-15w, in Russell County, topped Arbuckle at 3,291 ft. and was dry at total depth of 3,320 ft.

KANSAS SUCCESSFUL WILDCAT

Kiowa County: Stanolind Oil & Gas 1 Louis C. Repp, NE NE NW 29-28s-17w, gaged 7,300,000 cu. ft. of gas from Mississippian at 4,843-54 ft. through open tubing, anhydrite 1,136 ft., Lansing-Kansas City 4,277 ft., Viola 4,956 ft., Simpson 5,088 ft., Arbuckle 5,147 ft., TD 5,159 ft.

KANSAS WILDCAT FAILURES

Butler County: Rex & Morris 1 Wilson.



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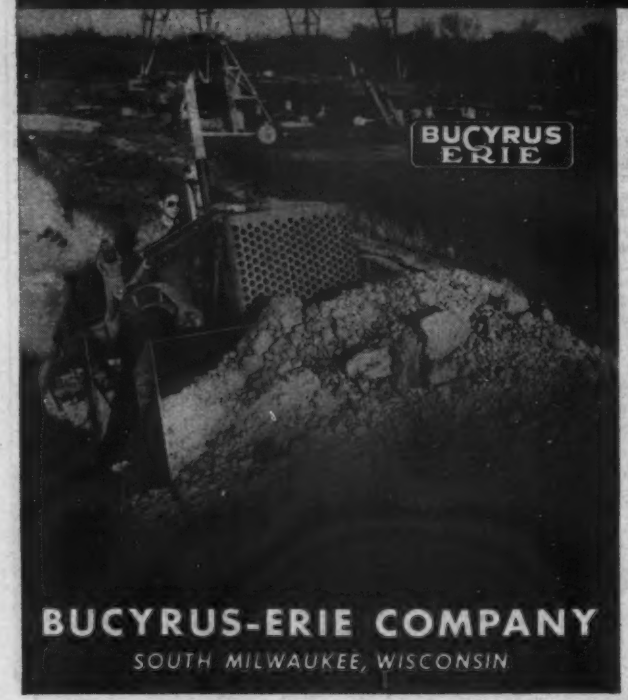
With Bucyrus-Erie Bullgraders & Bulldozers



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SOUTH MILWAUKEE, WISCONSIN

YOU CAN REDUCE the cost of oil field dirt moving by turning it over to Bucyrus-Erie hydraulic or cable controlled Bullgraders and bulldozers. Grading derrick locations, constructing access roads, building dikes for tanks, digging sump holes, clearing land for pipe lines are just a few of the many jobs that can be quickly and easily handled by these money-saving machines.

Bucyrus-Erie Bullgraders and bulldozers are so carefully designed to fit International crawler tractors that these tractors retain all of their operating characteristics and effectiveness. The weight of the equipment and the digging loads imposed are properly distributed to give you full advantage of all the power furnished by the tractor. This means more power at the blade, more dirt moved, less fuel burned. It also means lower repair costs, because even distribution of track roller loads prevents excessive wear and strain on tractor front idlers and rollers.

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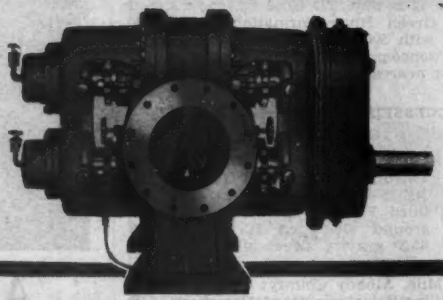

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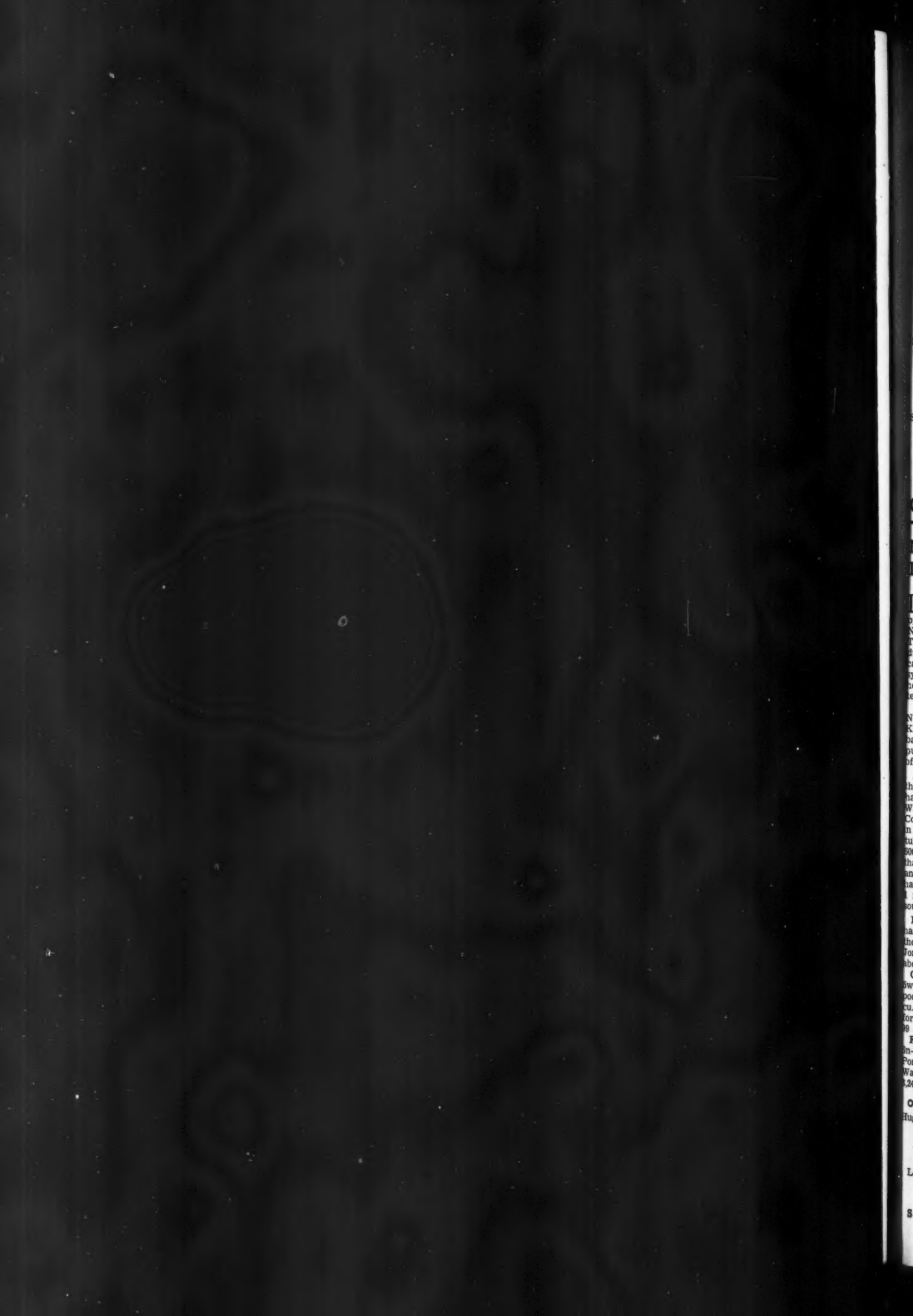

NW NW SE 24-25s-3e, dry, TD 2,697 ft., Mississippian 2,653 ft. with a show of oil.

Cowley County: Big Five 1 Bolack, NE NW NE 21-32s-6e, dry, TD 3,001 ft., Stalnaker 1,910 ft., Kansas City 2,229 ft., Layton 2,267 ft., Mississippian 2,965 ft.

Graham County: Anderson-Prichard and Texon 1 Griffith, SE SW SE 15-10s-22w, dry, TD 3,921 ft., Lansing-Kansas City 3,479 ft., Heebner 3,443 ft., conglomerate 3,798 ft., Arbuckle 3,856 ft.

McPherson County: Lowell Drilling 1 Greenwood, SW SW NE 28-18s-1w, dry, TD 3,365 ft., Lansing-Kansas City 2,220 ft., Mississippian 2,804 ft., Viola 3,330 ft.

Rooks County: Tom Palmer 1 Wickham, NE NE SW 4-10s-17w, dry, TD 3,548 ft., anhydrite 1,335 ft., Kansas City 3,226 ft., conglomerate 3,507 ft., Simpson 3,518 ft., Arbuckle 3,521 ft.

Rush County: Crown Oil Co. 1 J. Josefiak, SE SE NE 26-19s-19w, dry, TD 4,232 ft., anhydrite 1,390 ft., Heebner 3,664 ft., Lansing-Kansas City 3,710 ft., Marmaton 3,982 ft., conglomerate 4,082 ft., cherty conglomerate 4,138 ft., Arbuckle 4,180. ft.

Sheridan County: Cities Service Oil 1 Hansen "E." C N/2 SW NE 28-8s-26w, dry, TD 3,950 ft., Heebner 3,678 ft., Lansing-Kansas City 3,696 ft., Basal Kansas City 3,934 ft.

OKLAHOMA

New Pool Opener in Duncan District

DUNCAN NORTHEAST has been designated as the name of the new pool opened by Mudge Oil Co. 1 Sembritsky, SE NW SE 24-1n-7w, northeast of Duncan. This discovery looked much better on production tests than drill-stem tests had indicated, flowing 50 bbl. per hour from Pennsylvanian sand at 7,170-7,200 ft., on one 9-hour test. 40 bbl. per hour on a 20-hour test, and 60 bbl. per hour on a later test.

Royal Petroleum Co. 1 Krieger, NW NW NW 10-6n-17w, southeast of Hobart in Kiowa County, drilled to 1,497 ft., plugged back and perforated at 960-75 ft., and pumped 6 bbl. of oil and the same amount of water.

After second acidization, with 3,500 gal. this time, Stanolind Oil & Gas Co. 1 Reinhart, SW SW 30-13n-2w, south of the Witcher condensate pool in Oklahoma County, flowed 147 bbl. net of new oil in 23 hours through a 15/64-in. tubing choke, tubing pressure 275 psi., casing pressure 600 psi. This looks like an oil well, rather than condensate. Stanolind has announced an east 40-acre offset; Peppers Refining Co. has announced a location 1½ miles east and 1 mile south. The Peppers well is 2 miles south of the nearest condensate well.

Hall-Miller 1 Geisler, NE NE SE 26-13n-1e, has been completed as a 200-bbl. well from the Cleveland sand pay, to extend the Jones field in eastern Oklahoma County about 1 mile southeast.

Gilmer Oil Co. 1 Creel, NE SE NW 5-1s-5w, about 2 miles northwest of the Velma pool in Stephens County, gaged 9,300,000 cu. ft. of gas and a spray of oil from perforations at 6,265-6,303 ft., 6,407-13 ft., 6,350-69 ft., and 6,411-46 ft.

F. L. Cooper 1 Marshall, NE NE NW 31-3n-4e, a mile south of the Asher pool in Pontotoc County, had saturation in the Wanette sand and on drill-stem test at 3,249-52 ft., recovered 140 ft. of oil.

OKLAHOMA SUCCESSFUL WILDCATS

Hughes County: Mid-Continent 1 McAfee, SE SE SE 2-9n-11e, produced 8,500,000 cu ft. of gas from Gilcrease sand at 2,955-80 ft.; Booch 2,241 ft., Wapanucka 3,150 ft., Cromwell 3,330 ft., TD 3,420 ft.

Lario Oil & Gas 1 Fream, SW SW NE 33-7n-8e, pumped 25 bbl. of 33°-gravity oil per day from Booch at 2,750-65 ft. and 2,820-41 ft.; brown lime 2,656 ft., Gilcrease 3,019-3,305 ft., first Cromwell 3,488-3,504 ft., second Cromwell 3,507 ft., TD 3,514 ft.

Kiowa County: Royal Petroleum 1 Krieger, NW NW NW 10-6n-17w, pumped 6 bbl. of 21°-gravity oil per day from 860-908 ft., TD 1,502 ft., no tops reported, tight hole.

Okfuskee County: Extension to West Morse Senate Oil Co. (J. D. Hancock) 1 Woodward, SE SE SE 13-12n-9e, pumped 40 bbl. of oil per day from 3,076-90 ft.; Inola 2,435 ft., Bartlesville 2,450 ft., sand 2,556-2,652 ft., Booch 2,763 ft., Gilcrease 2,937 ft., Wapanucka 3,219 ft., TD 3,259 ft.

Pawnee County: Previous completion—Bay Petroleum & H. H. & B. Drilling 1 Sara Smith, C E/2 NE NE 12-21s-16w, produced 273 bbl. of oil per day from Arbuckle at 3,785-88 ft., TD 3,788 ft., OWDD, opened South Ask Creek pool.

Pottawatomie County: Deep Rock et al 1 Black, SE SE NW 17-10n-2e, flowed 175 bbl. of 37.2°-gravity oil per day from Wilcox at 6,021-26 ft. through 11/64-in. tubing choke, Belle City 3,685 ft., Checkerboard 4,355 ft., Oswego 5,140 ft., Skinner 5,270 ft., Earlsboro 5,361 ft., Woodford 5,492 ft., Chimney Hill 5,625 ft., Sylvan 5,771 ft., Viola 5,872 ft., dense 5,911 ft., sandy dolomite 5,963 ft., TD 6,026 ft.

OKLAHOMA WILDCAT FAILURES

Comanche County: J. C. Meigs 1 Johns, NW NW NW 9-1n-10w, dry, TD 600 ft., no tops reported.

Cotton County: E. C. Harlin, Jr. 1 Gover, NW NW NE 29-4s-9w, dry, TD 2,110 ft., conglomerate 637-52 ft., lime and shale 1,308-10 ft., lime 1,336-38 ft., sand 1,502-11 ft. and 1,717-32 ft.

Kelleher et al 2 Ka-Hin-A-Watch-It, NW NW NE 12-3s-12w, dry, TD 1,809 ft., sand 1,551-56 ft., sandy shale 1,590-95

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FOR HEATING, REFRIGERATION, AIR CONDITIONING, ENGINES, PUMPS AND AIR COMPRESSORS

ft., sand and shale 1,706-15 ft., white sand 1,759-73 ft., no shows.

Garfield County: Dave Morgan Oil 1 Kingery, NW NW SE 13-23n-3w, dry, TD 4,650 ft., lime 3,852-64 ft., Hogshooter 3,878-3,906 ft., Checkerboard 4,015 ft., Big lime 4,153 ft., Oswego 4,202 ft., Bartlesville 4,345 ft., Mississippi lime 4,443 ft., Woodford 4,475 ft., Viola 4,530 ft., dolomite 4,554-79 ft., Wilcox 4,588-4,622 ft., second Wilcox 4,639 ft.

Hughes County: Kingery & Patterson 1 Gilmore, NE SE SE 7-5n-9e, dry, TD 2,693 ft., Senora lime 830 ft., brown lime 2,440 ft., first Booch 2,578 ft., second Booch 2,678 ft.

King 1 Chupco, NE SE SW 28-7n-9e, dry, TD 3,013 ft., Senora lime 1,205 ft., Senora sand 1,290-1,308 ft., Bartlesville 2,397-2,466 ft., Upper Booch 2,872-2,906 ft., coal 2,982 ft., Lower Booch 2,988 ft.

Jefferson County: Reno Oil 1 Scheer, NE NE NE 26-7s-6w, dry, TD 2,030 ft., broken sands and lime 470-1,860 ft., sandy shale 1,959-2,010 ft.

Hedrick Oil Co., Ltd., 1 Majors, NW NW NW 10-6s-6w, dry, TD 3,042 ft., sand 930-40 ft., lime 1,610-34 ft., Arbuckle 2,912 ft.

Noble County: Deep Rock 1 McCormick, SW SE SW 1-23n-1w, dry, TD 5,063 ft., Pawhuska 2,060 ft., Hoover 2,164 ft., Elgin 2,300 ft., Oread 2,431 ft., sand 2,562 ft., Tonkawa lime 2,732 ft., Osage Layton 3,475 ft., Oswego 4,032 ft., Cherokee 4,199 ft., Red Fork 4,416 ft., Mississippi lime 4,590 ft., Woodford 4,925 ft., Viola 4,959 ft., dense 4,972 ft., sandy dolomite 5,004 ft., Wilcox 5,013-40 ft., second Wilcox 5,050 ft.

Oklahoma County: Harper-Turner 1 Duncan, NE NE SW 22-14n-2w, dry, TD 6,016 ft., Oswego 5,478 ft., Bartlesville 5,748 ft., Basal Pennsylvanian-Woodford 5,840 ft., Hunton 5,878 ft., Sylvan 5,997 ft.

Okfuskee County: Russell Maguire 1 Pauley, SW SW SE 8-10n-9e, dry, TD 1,841 ft., Wewoka 950-1,135 ft., coal 1,756 ft., sand 1,768 ft. with a slight stain of oil.

Pawnee County: H. H. Taylor 1 Garrett, NW SW SE 20-22n-6e, dry, TD 3,448 ft., Skinner 2,760-70 ft., Mississippi lime 2,968-3,144 ft., Woodford 3,144 ft., Simpson 3,165 ft., Wilcox 3,167 ft., Arbuckle 3,398 ft.

Pontotoc County: Southwestern Natural Gas 1 Hynds, NE NW NW 24-4n-6e, dry, TD 2,940 ft., Senora lime 960 ft., Wapanucka 1,715 ft., Mississippian-Caney 2,480 ft., Woodford 2,750 ft., Hunton 2,871 ft.

Stephens County: Skelly 1 Woodworth, NE NE SW 10-2s-4w, dry, TD 4,418 ft., Hoxbar 1,530 ft., Basal Pennsylvanian-Woodford 4,380 ft.

Tillman County: W. G. Gouchie 1 Allgood, NE SE SE 18-1n-18w, dry, TD 1,138 ft., no tops reported.

Three Oklahoma Indian Agencies Consolidated

The Pawnee Indian Agency, Shawnee Indian Agency, and Cheyenne and Arapaho Indian Agency have been abolished and their functions absorbed by the Kiowa Indian Agency, to be known as the Western Oklahoma Consolidated Indian Agency with headquarters in the Federal building at Anadarko, Oklahoma.

John T. Montgomery, acting superintendent and special disbursing agent, will now have jurisdiction over such matters as correspondence about oil and gas leases, assignments, cancellations, payment of rentals and other related matters.

Ashland to Build Third Ohio River Terminal

Plans for the construction of another large petroleum terminal on the Ohio River have been announced by Paul G. Blazer, chairman of the board, Ashland Oil & Refining Co.

The company has purchased a 30-acre site at Clarksville, Ind., opposite the business district of Louisville, Ky., where it will soon begin the construction of a river landing, storage tanks, rail and truck loading racks, and installation of the necessary pipes and pumps.

The Clarksville terminal will serve as a distributing point through a large section of Kentucky south of Louisville as well as in Louisville, itself, and southern Indiana. It will receive gasoline and other finished products by barge from the company's refinery near Catlettsburg, Ky. This will be the company's third large river distributing terminal, the others being at Floreffe, Pa., near Pittsburgh, and at Covington, Ky., opposite Cincinnati.

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Among the Drilling Contractors

Calvert & Willis Active In Illinois and Indiana

Calvert & Willis, Inc., Olney, Ill., currently have three rigs running in Illinois as follows: W. O. Morgan and Calvert & Willis, Inc. 1 Walker heirs, a semiwildcat south of Browns, Edwards County; Inland Producers, Inc. 3 Harms, in Bone Gap South field, Edwards County; and Vincent J. Nolan and Calvert & Willis, Inc. 1 Twist, SE SE SE 10-4s-7e, a wildcat in Hamilton County.

During the period August 14-September 4, Calvert & Willis and associates drilled and completed nine Mansfield sand wells in the new Evansville field opened by themselves in 2-6s-11w, Vanderburg County, Indiana. These wells were drilled to an average depth of 890 ft. and eight producers were hit which are now pumping 350 bbl. daily.

Active rotary drilling rigs in the United States reached an all-time high of 1,985 in August, breaking all previous records for the second consecutive month . . . see story in News Developments section.

Loffland Brothers Start Long Beach Program

Loffland Brothers Co., Tulsa, is starting operations soon on the first 24 wells which Richfield Oil Corp. will drill in its big development program in the Long Beach, Calif., harbor area. Tentative plans call for the drilling of 75-100 wells on a 245-acre lease acquired by Richfield from the city of Long Beach. Cellars have been constructed and conductor pipes driven for the first 24 wells which will be directionally drilled out under the harbor.

Crissman Drilling Co., Long Beach, is the contractor for three wells for Porter Sesnon et al, and for two additional wells for others, to the Tar sand in Huntington Beach field, California.

H. E. Walton has purchased a rotary rig from Scott Drilling, Inc., and entered the contract drilling business in Michigan.

Meredith, Clegg & Hunt, Houston, are rigging up on the 1 Guaranty Title & Trust Co., Nueces County, Texas, for Tide Water Associated Oil

Crew of Olson Drilling Co., Tulsa, on the Harrison 1 Carter, Garvin County, Oklahoma. Perry Pearce, toolpusher for Britain-Corbitt Drilling Co., Oklahoma City, is on the left. Crew members are: Joe Smallwood; Cecil Hamilton, driller; Jim Parker, Travis Butler, and W. E. Hites

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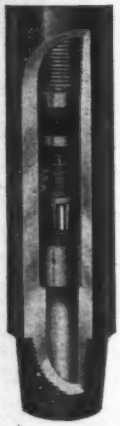

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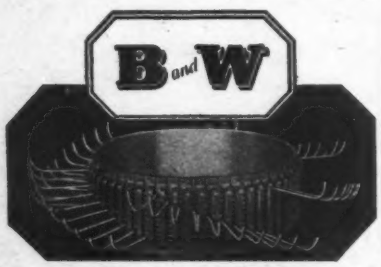

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Co. This well is near the Corpus Christi municipal airport. Contract depth is 10,500 ft.

Harbar Drilling Co., Wichita, has contract and an interest in Emergency Export Corp. and Artnell Co. 1 Interstate Cattle & Logan Co., a wildcat 14 miles west of Hugoton gas field and 5 miles east of Colorado line in Morton County, Kansas. The test is scheduled for the Arbuckle and is in C NW NW 12-34-43. Gulf Oil Corp. farmed out the 640-acre drill site.

E. F. Moran, Tulsa, will drill a 11,000-ft. test for Argo Oil Co. in Reeves County, West Texas. The test is the 1 Ikins, Section 293, Block 13, H&GN Survey.

J. N. Cannon is the contractor for a 5,000-ft. test for C. & B. Oil Co., the 1 Monroe, a wildcat in Section 13, Block 2, H&GN Survey, 6 miles west of Wheat pool, Reeves County, Texas.

Phillip M. King will drill Atlantic Refining Co. 1 Fee, Section 1, Block 1, MK&T Survey, 8 miles east of McCamey, Upton County, West Texas, as a 2,250-ft. cable-tool wildcat to test the Grayburg. Location is on a 120-acre lease farmed out by Atlantic to Ralph Fitting and Dave DeVito, Midland, who turned the acreage over to King for drilling.

Rine Drilling Co., Great Bend, Kans., is drilling a wildcat for Lion Oil Co. 1 mile east of Trapp pool, Barton County, Kansas. The test is 1 Michael, NW SE NW 15-16-13.

Ray Pool, Odessa, Tex., is moving in for Bobby Manziel 1 Shamburger, in northwest of a 160-acre lease, J. W. Stewart Survey A-931, on south side of Sand Flats field, Smith County, East Texas. Contract is for 7,800 ft.

Hackathorn Drilling Co. has completed a 200,000-cu. ft. gas well, its 1 Ashing Ranch, at Ridgeway, Ouray County, Colorado. Pay was reached at 410 ft. in the Dakota.

Clay & Sons Drilling Co. has staked location for its 1 School Land, C SE NW 36-6n-2e, a wildcat, Pottawatomie County, Oklahoma.

Allen & Morris Drilling Co., San Antonio, has been the contractor on the last four wells drilled in McAllen gas field, Hidalgo County, Southwest Texas. A dual completion, first in the field, is being attempted on the last well drilled, the Coastal Refineries, Inc.-Mayfair Minerals, Inc., 1 Laura V. Harding, near the northeast city limits of McAllen.

Acme Drilling Co. has been organized in California and maintains an office at 3095 Cherry Avenue in Long Beach, and 448 South Hill Street in Los Angeles.

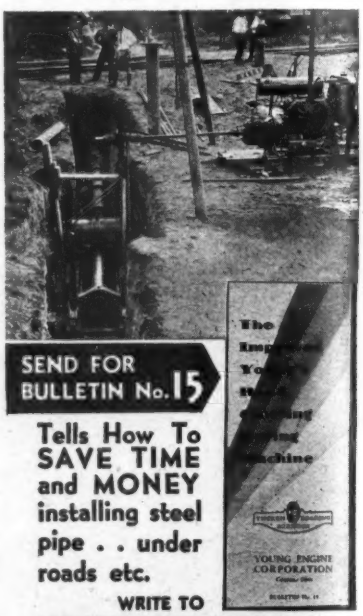
E. K. Carey, McPherson, Kans., is under contract for a Sumner County, Kansas, test, the W. C. McBride and Derby Oil Co. 1 Kraft, SE SE SW 28-30-1w, 3 miles southwest of Southwest Zyba pool and 5 miles north of Wellington pool.

Louis Mabee, Midland, Tex., has contract to drill Joe Josephson, Dallas, 1 O. K. Oliver, in Section 27, Block M, EL Survey, in northwest Dawson County, West Texas. Location is 4 miles east and 2 miles south of the town of Welch, and 2 miles east of nearest production in Welch field. It is scheduled to 5,100 ft.

Barnes & Shadrick, Bakersfield, will drill Fisher and Maurer 2 Linda, a wildcat southeast of Round Mountain field, Kern County, California.

Coppinger & Southern, Wichita, are drilling W. C. McBride et al 1 Kraus, SE SE SE 16-14-19, Ellis County, Kansas.

C. M. Bagley Drilling Co., Shreveport, is drilling Harry N. Morris 1 Lula Patterson, in 28-22n-1e, Union Parish, North Louisiana. Location is 3 miles southeast of the Ora discovery well, where production is from



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the Nacatoch sand around 2,200 ft. Contract calls for testing to 3,000 ft. to explore the Tuscaloosa.

Bell & Burden, Compton, Calif., are drilling Continental Oil Co. 54 Grubb in San Miguelito field, Ventura County, California.

Transit Corp. is rigging up for a wildcat the Anderson-Prichard Oil Co. 1 McCormick, NE NE NW 6-8-19, Rooks County, Kansas.

Phinney Bros., Allegan, Mich., will drill Dale M. Leonard 1 John Jourtis, SE NE NW 24-13n-17w, Oceana County, Michigan. This test is one township east of Carter's Stony Lake field.

E. M. Shields, Butler, Pa., has contract for a wildcat for Socony-Vacuum Oil Co., Inc., the 1 Smeyer and Van Stratt, SE SE SW 26-7n-15w, Ottawa County, Michigan.

M. C. A. Drilling Co. has contract to redrill several wells for The Texas Co. on its Glide lease in Mount Poso field, Kern County, California.

Wise Drilling Co. has contract for an East Texas wildcat, the O. W. Killam 1 J. M. McKee, on a 32-acre tract, Walter F. Poole Survey A-57, 4 miles southeast of Frankston, Anderson County. Contract is for 5,000 ft.

Herndon Drilling Co., Tulsa, has brought in a wildcat gas well for Stanolind Oil & Gas Co. in Kiowa County, Kansas. The test is 1 L. C. Reop, NE NE NW 29-28-17, and is producing from the Mississippi at 4,843-54 ft.

Northern Development Co., Edmonton, Alta., has the contract with Globe Oil Co. for three wells to be drilled in Leduc field on the same quarter-section as Globe-Leduc West 2 producer. Outfit from the producer will be moved to No. 3 and a new rig used for No. 4.

Wentworth Drilling Co., Tulsa, has been issued incorporation papers by the Oklahoma secretary of state. Capital stock of the company is $200,000 and incorporators are Claude, Donald R. and E. H. Wentworth, all of Tulsa.

Gene Reid Drilling, Inc., Bakersfield, has contract for Sunray Oil Corp. 1 Richardson, a wildcat in Alpaugh area, Tulare County, California. Sunray is looking for a gas field with this test which is 3 miles north of Trico gas field.

Coats & Foster Drilling Co., Lubbock, Tex., has started a 4,300-ft. test, its 1 C. A. Scott, on a 149.84-acre tract, William McLelland Survey A-642, 2 miles east of Comyn, Comanche County, Texas.

Designed for portable drilling rigs, workovers and for handling small sizes of drill pipe on the largest rigs, this tong has proven most popular and successful. All diameters from 2⅜" to 8⅜" are perfectly gripped by using proper size latch lug jaws. Tong can be equipped with either short or standard levers, dependent on derrick conditions. Hinge pin holes are flame hardened to insure long trouble-free life. This tong, like the BJ type "B," is designed to meet unusually tough service conditions.

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STATISTICS and

WEEKLY WELL COMPLETIONS . . . WEEK ENDED SEPTEMBER 13, 1947

	Total of all wells					Cum.		Wildcat completions and discoveries					Cumulative total, 1947				
	Comp.	Oil	Gas	Dry	Footage	1947	1946	Oil	Dist.	Gas	Dry	Total	Oil	Dist.	Gas	Dry	Total
New York	45	22	0	*23	64,350	1,133	1,112	0	0	0	0	0	3	0	0	2	5
Pennsylvania	67	37	0	†30	101,712	2,051	2,802	0	0	0	0	0	0	0	3	1	4
West Virginia	17	2	13	2	47,739	588	516	0	0	0	0	0	0	0	14	7	21
Ohio	27	3	13	‡11	72,020	915	853	0	0	1	0	1	0	0	4	32	36
Indiana	17	9	0	8	26,460	450	256	0	0	0	•0	0	20	0	0	33	53
Kentucky	24	11	7	6	27,178	483	339	0	0	0	0	0	8	0	0	32	40
Illinois	48	26	0	22	121,854	1,411	1,562	3	0	0	8	11	51	0	1	245	297
Michigan	14	5	4	5	29,989	599	574	1	0	0	4	5	7	0	10	156	173
Kansas	50	28	4	18	158,934	1,800	1,385	0	0	1	7	8	29	0	12	244	285
Neb., Mo., Iowa	0	0	0	0	0	4	15	0	0	0	0	0	0	0	0	4	4
Oklahoma	75	40	2	‡33	197,959	2,894	1,900	5	0	1	15	21	77	5	13	487	582
Texas	193	126	7	60	859,272	6,341	5,609	4	1	1	26	32	202	45	62	952	1,261
North Central (Dist. 7-B & 9)	60	31	1	28	165,106	2,057	2,010	0	0	0	9	9	62	0	8	325	395
West (Dist. 7-C & 8)	45	42	0	3	203,477	1,525	1,208	1	0	0	3	4	22	0	3	115	140
Panhandle (Dist. 10)	11	9	2	0	34,644	306	229	0	0	0	0	0	1	0	1	8	10
Eastern (Dist. 5 & 6)	13	7	3	3	61,252	361	517	0	0	0	2	2	5	1	4	78	88
Gulf Coast (Dist. 3)	32	16	0	16	217,826	1,101	1,224	0	1	0	6	7	51	33	26	199	309
Southwest (Dist. 1, 2 & 4)	32	21	1	10	176,967	991	421	3	0	1	6	10	61	11	20	227	319
Louisiana	37	25	1	11	169,958	1,025	953	0	0	0	7	7	27	17	9	143	196
Northern	24	16	1	7	54,193	580	529	0	0	0	5	5	3	1	3	86	93
Southern	13	9	0	4	115,165	445	424	0	0	0	2	2	24	16	6	57	103
Arkansas	9	4	0	5	31,409	202	124	0	0	0	1	1	1	0	0	40	41
Mississippi	4	3	0	1	33,663	336	170	0	0	0	1	1	0	0	1	64	65
Southeastern States	1	0	0	1	4,571	41	30	0	0	0	1	1	0	0	0	36	36
Montana	6	1	3	2	9,718	189	219	0	0	0	0	0	4	0	5	17	26
Wyoming	10	7	2	1	53,330	163	122	2	0	1	1	4	11	0	3	25	39
Colorado-Utah	4	2	0	2	17,915	139	103	0	0	0	2	2	2	0	1	36	39
New Mexico	10	10	0	0	41,238	366	265	1	0	0	0	1	5	0	1	26	32
California	33	25	0	8	177,676	1,349	1,180	1	0	0	6	7	36	0	6	194	236
Total United States	691	386	56	249	2,246,945	22,479	20,089	17	1	5	79	102	483	67	145	2,776	3,471
Total previous week	713	366	67	280	2,346,886	21,788	19,492	21	3	2	100	126	466	66	140	2,697	3,369
Total Sept. 14, 1946	597	306	66	225	1,975,854			16	1	3	83	103	385	29	86	2,375	2,875

Service wells included: *23, †30, ‡2.

CRUDE PRICES AND REFINERY ACTIVITY

GRAVITY SCHEDULES

Top prices include all gravities above grades designated, and low prices include all gravities below grades designated:

Gravity—	Signal Hill, Calif.*	Oklahoma, Kansas	Gulf Coast Tex.†	West Tex.‡
18-18.9	$1.60	....	....	....
19-19.9	1.65	....	....	....
20-20.9	1.69	$1.55	....	$1.42
21-21.9	1.73	1.57	....	1.44
22-22.9	1.77	1.59	....	1.46
23-23.9	1.80	1.61	....	1.48
24-24.9	1.84	1.63	$1.86	1.50
25-25.9	1.88	1.65	1.88	1.52
26-26.9	1.91	1.67	1.90	1.54
27-27.9	1.95	1.69	1.92	1.56
28-28.9	1.99	1.71	1.94	1.58
29-29.9	2.02	1.73	1.96	1.60
30-30.9	2.06	1.75	1.98	1.62
31-31.9	....	1.77	2.00	1.64
32-32.9	....	1.79	2.02	1.66
33-33.9	....	1.81	2.04	1.68
34-34.9	....	1.83	2.06	1.70
35-35.9	....	1.85	2.08	1.72
36-36.9	....	1.87	2.10	1.74
37-37.9	....	1.89	2.12	1.76
38-38.9	....	1.91	2.14	1.78
39-39.9	....	1.93	2.16	1.80
40 and above	....	1.95	2.18	1.82

*Standard Oil Co. of Calif. posting. †For crude from Daboval, El Campo, and Sandy Point. ‡Includes Lea County, New Mexico.

A.P.I. REINERY REPORT, WEEK ENDED SEPTEMBER 6

(Thousands of barrels)

District—	Crude runs, daily avg.	Production: Gasoline†	Kerosine	Gas & dist. oil	Residual	Stocks at refineries, bulk terminals, in transit and in pipe lines: Gasoline*	Kerosine	Gas & dist. oil	Residual
East Coast	850	2,106	324	1,133	1,532	19,449	8,653	17,283	10,029
Appalachian:									
District 1	100	307	37	84	89	2,149	376	606	329
District 2	62	229	15	38	98	850	166	223	204
Ind., Ill., Ky.	838	2,983	273	841	1,091	14,700	2,941	7,554	5,233
Okla., Kans., Mo.	437	1,537	122	510	503	6,863	1,216	3,165	1,470
Inland Texas	238	991	108	161	415	2,693	551	571	902
Texas Gulf Coast	1,235	3,827	579	1,756	1,844	13,575	3,202	9,042	7,058
La. Gulf Coast	414	1,261	328	593	523	4,496	2,313	2,749	1,878
N. La. and Ark.	70	177	49	57	120	1,505	460	330	205
Rocky Mountain:									
New Mexico	13	41	4	11	19	87	15	21	33
Other Rocky Mtn.	129	464	10	152	212	1,770	159	904	748
California	860	2,282	68	1,001	2,262	15,199	1,050	14,315	28,079
September 6, 1947	5,246	16,205	1,917	6,337	8,708	83,336	21,102	56,763	56,168
August 30, 1947	5,209	16,753	1,910	5,919	8,962	84,105	20,723	54,808	55,242
September 7, 1946	4,876	15,406	1,821	5,509	8,102	86,909	19,990	55,626	54,936

*Finished and unfinished. †At refineries including natural blended.

Bureau of Mines crude-oil stocks 226,154,000 bbl. as of September 9—down 2,127,000 bbl. One year ago 223,132,000 bbl.

FLAT CRUDE PRICES

Representative posted schedules per bbl.			
East Texas	$1.95	Pecos County, Texas (Yates)	1.65
Kettleman Hills, California*	2.14	Bradford, Pennsylvania	4.50
Beauregard Parish	1.90	Eastern Ill. and Western Ind.†	2.07
Illinois Basin	2.07	Tomball, Texas Gulf Coast	2.10

*37°-37.9°. †35° and above.

TRENDS

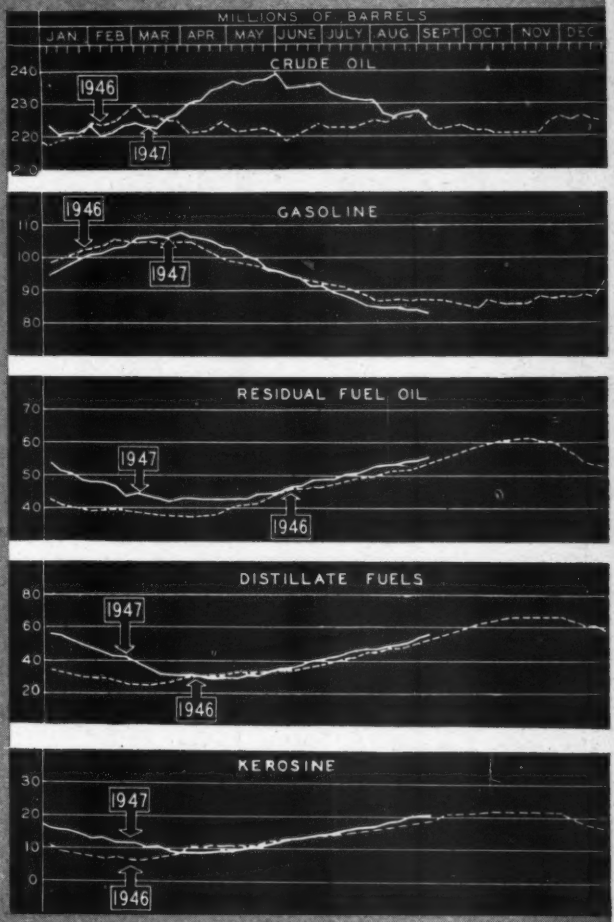
DAILY AVERAGE PRODUCTION FOR WEEK

	Sept. 13 crude oil	B. of M. Sept. demand	Sept. 6 crude oil
Alabama	1,100	1,000	1,100
Arkansas	82,350	82,000	81,950
California	924,900	930,000	925,300
Colorado	44,320	44,000	44,240
Eastern	61,800	65,400	62,000
Florida	1,050	1,000	1,100
Illinois	175,800	200,000	178,900
Indiana	18,200	18,000	17,500
Kansas	298,900	309,000	284,750
Kentucky	25,600	27,000	25,800
Louisiana	440,950	445,000	439,525
North Louisiana	108,350	.....	107,300
South Louisiana	332,600	.....	332,225
Michigan	51,165	45,000	43,490
Mississippi	103,405	99,000	99,250
Montana	25,000	24,000	23,880
Nebraska	600	600	550
New Mexico	117,350	110,000	116,000
Oklahoma	399,050	405,000	396,300
Texas	2,333,755	2,290,000	2,328,675
Dist. 1 (Southwest)	24,275	.....	24,150
Dist. 2 (Southwest)	160,675	.....	160,500
Dist. 4 (Southwest	247,600	.....	246,700
Dist. 3 (Gulf Coast)	499,875	.....	498,000
Dist. 5 (Eastern)	40,875	.....	40,675
Dist. 6 (Eastern)	118,605	.....	118,225
East Texas Field	308,000	.....	310,275
Dist. 7-C (West)	41,260	.....	41,000
Dist. 8 (West)	637,650	.....	634,950
Dist. 7-B (W. Central)	40,975	.....	40,725
Dist. 9 (N. Central)	127,725	.....	127,625
Dist. 10 (Panhandle)	86,240	.....	85,850
Wyoming	120,790	124,000	118,790
Total United States	*5,226,085	5,220,000	5,189,100
Change from prev. wk., up	36,985		

Total production January 1-September 13 †1,277,431,730 bbl.
Same period last year (crude plus cond.) 1,213,523,185 bbl.

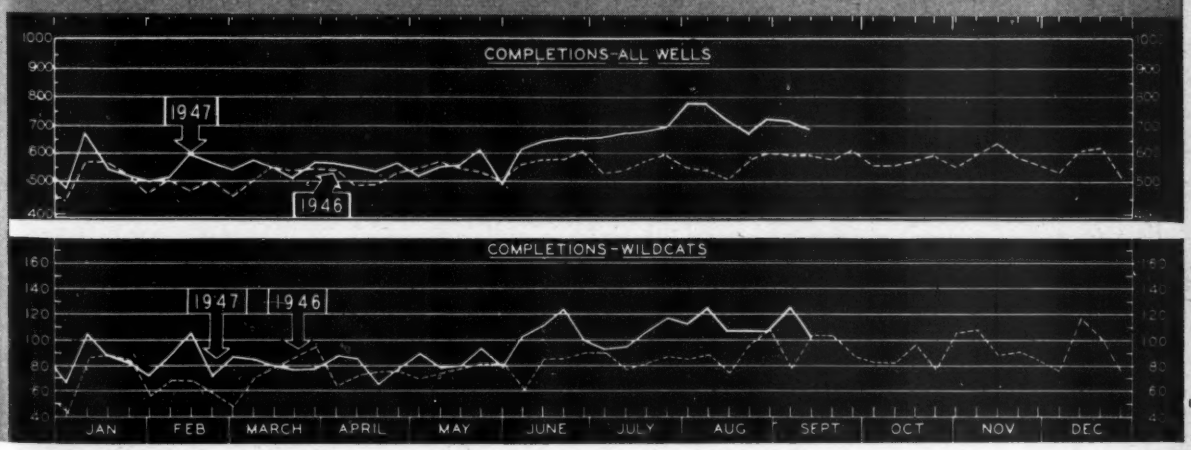
*Not incl. 41,910 bbl. condensate. †Incl. 8,029,240 bbl. condensate.

OIL STOCKS IN THE UNITED STATES



DAILY OPERATIONS

Solid line charts weekly completions, service wells in Eastern area included.



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MARKETS

FIRST major effect of Standard Oil Co. (N.J.) "hold - the - line" price policy came September 11 when The Texas Co. announced it was reducing prices in nine eastern and southern states and the District of Columbia.

Officials of The Texas Co. said local dealers in the area had been "authorized to meet the competitive prices" of Standard of Jersey. Texaco's price rollback ranged up to 1 cent a gallon on gasoline and about 4/10 cent on light fuel oil.

Shell Oil Co., Inc., and Pure Oil Co. met the lower prices, and a Sinclair Refining Co. official indicated his company also would follow. Oil-marketing circles in New York were closely watching results of Jersey Standard's fight against the current upward market trend. Several other companies were reported to be feeling the effect of Jersey's lower prices.

Other Areas Unaffected

Little chance was seen that the lower prices would have any direct effect elsewhere in the country where other companies are in the position of market leader. On the Gulf Coast, one source said the Jersey policy probably would continue to cause "high spread" market quotations until demand slackens.

Principal feature of petroleum markets in the Mid-Continent last week was some softness in residual fuel oil. This appeared to be caused by full consumer storage tanks at the commencement of cold weather, labor troubles in the steel industry, and temporary shutdown of two cracking units of Standard Oil Co. (Ind.), because of fires.

While No. 6 was selling at prices ranging up to $2.40 a few weeks back, it was said to be fairly easy to obtain good-quality material at $2 per barrel.

In other products, market demand continued high. One Mid-Continent marketer said he noticed a "very slight easing" in the motor-fuel supply situation. No. 2 continued to command premiums ranging up to a cent on the spot market, but little was available. One major refiner quoted, spot market, Group 3, 7 cents for No. 2, $2 for No. 6, 8¾ for regular gasoline, and 10 cents for Ethyl.

Gulf Coast Situation

On the Gulf Coast, gasoline and light fuel oils were described as still unobtainable. A small quantity of 41-43 kerosine was reported to have moved at 8 cents. Distillate fuel oils were said to be continuing to go to storage in quantity, partly in anticipation of higher prices in the East this winter.

One major buyer was reported to have withdrawn from the heavy fuel oil market, possibly presaging some downturn in this product similar to the current softness in the Mid-Continent. Marketing officials on the Gulf Coast were wary for any signs of a slump in the export market in view of the current move of several governments to conserve dollar reserves. Some apparent improvement in supply of Gulf Coast lubricating oils resulted in slightly lower prices for several grades.

An American Petroleum Institute compilation showed national gasoline consumption the first 6 months to be 8.8 per cent above the first half of 1946. The Department of Commerce reported July sales by petroleum wholesalers were 21 per cent above July 1946.

Representative Quotations

Representative spot-market quotations of leading suppliers as of September 15, 1947. Figures are f.o.b. plant for tank-car shipment in cents per gallon, except for residual fuel oil which shows the price per barrel and wax, in cents per pound.

GASOLINE, KEROSINE, AND FUEL OILS

	Mid-Continent Group 3	New York Harbor	Texas Gulf Coast
Regular gasoline, 73-75 octane	8¾-9½	10.5-10.9* 9.3-9.10†	9-10½
42-44 w.w. kerosine	7½-8	7.8-8.3	7½-8
No. 2 straw fuel oil	6⅞-7⅛	6.8-7.2	7¾
Premium gasoline, 78-89 octane	9½-11¼	10.2-12	9½-11½
No. 6 residual	$2-2.45	$2.22-2.52	$2.00-2.75

*Branded (74-76 octane); †Unbranded (74-76 octane).

NATURAL GASOLINE

	Group 3	North Texas	N. La.
Grade 26-70	6⅜	5⅞	6⅛
Grade 18-55	7.65	7.05	7.35

LUBRICATING OILS

South Texas

200 vis., No. 2-3 neutral	11-12¼
750 vis., No. 3-4 neutral	13-14½
2,000 No. 5-6 neutral	14½-16

LUBRICATING OILS

Mid-Continent

150-160 vis., D bright stock, 0-10 p.p.	29
200 vis. No. 3 neutral, 0-10 p.p.	18-19

Western Pennsylvania

145-155 vis. 10 p.t. bright stock	45
180 vis. p.t. neutral	43

CRUDE-SCALE WAX

Mid-Continent

130-132 A.S.T.M. melting point	6¾-7¾

EQUIPMENT MEN ... in the News

Norris Announces New Sales Representative

J. A. GETTY

W. C. Norris, Manufacturer, announces the addition of John A. (Jack) Getty to its staff as field salesman at Shreveport to replace Arthur Miller who has been transferred to Tulsa as city salesman. Getty is a graduate engineer of University of Oklahoma and was formerly with American Manufacturing Co. His sales work was interrupted by World War II during which he spent 4½ years in the Army and was discharged as major.

Core Lab Announces New Engineering Firm

Core Laboratories, Inc., has announced the disassociation of its engineering and research departments and their reorganization into a new firm to be headed by James A. Lewis, recently resigned president of Core Lab.

Lewis' firm will engage in reservoir engineering, consultation, and allied operations, and will continue to do engineering and research work for Core Lab, as well as for the industry. The new firm, to be known as James A. Lewis, Engineering, will headquarter in Dallas. Core Lab's operations in the Illinois, Indiana, and Kentucky territory will be operated by the new organization under a license arrangement.

Core Laboratories, Inc., under the general managership of W. H. Davison, vice president, will continue to operate as a service organization for core analysis through the use of portable field laboratories and frozen cores; reservoir fluid analysis; well sampling; a new service of drill-cuttings analysis; and several new procedures and techniques to be announced at an early date.

Dr. Lindvall Elected to Board

Dr. Fred G. Lindvall has been elected to the board of directors of Consolidated Engineering Corp., Pasadena, Calif. Dr. Lindvall received his Ph.D. in electrical engineering in 1928 from California Institute of Technology. In the field of education, Dr. Lindvall is professor of electrical and mechanical engineering and chairman of the division of civil and mechanical engineering and aeronautics at Caltech.

Alco Products Moves To Dunkirk

Headquarters offices of Alco Production Division of the American Locomotive Co. have been transferred from New York to Dunkirk, N. Y. Hugh M. Corrough, director of the division, will direct all sales, engineering, and manufacturing from the Alco plant there.

Warren and Koons in Houston Office

Robert S. (Bob) Warren recently has joined Guiberson Corp., Dallas, as its Houston district sales repre-

R. S. WARREN

W. D. KOONS

sentative. For the past 9 years Warren has been with Thornhill-Craver as Houston sales representative, and prior to that he had been associated with Mid-Continent Supply Co. W. D. Koons, sales and service representative in the Houston office of the company for the past year, will remain in his present capacity.

Buda Names Campbell

Buda Co. announces the appointment of Harry G. Campbell as sales manager of DieseLight Division of Buda Co., Harvey, Ill. The division handles sales and manufacture of diesel-electric and gasoline-electric generator sets. Campbell's past experience includes 15 years with the Westinghouse Electric & Manufacturing Co. at Pittsburgh in the sales and manufacture of generator sets; and 5 years as a manufacturer's representative handling the sale of engine-generator sets in the states of Illinois, Kentucky, and Arkansas.

Palmer and Potgieter Elected Vice Presidents

Two new vice presidents have been elected in Mechanics Universal Joint Division of Borg-Warner Corp. C. E. Palmer, former works manager, was named vice president in charge of manufacturing for both the division's plants—the one in operation at Rockford, Ill., and the one now under construction in Memphis. The other newly elected vice president is Fred M. Potgieter, who will have charge of truck, agricultural implement, industrial, and aviation sales. G. C. Gridley was reelected president and general manager. R. R. Rolph was reelected vice president in charge of automotive sales.

Dresser and B.S.& B. Win Report Award

Two oil-field equipment manufacturers have been awarded "Oscars of Industry" for their 1946 annual report to stockholders. For the second consectutive year the annual report of Dresser Industries, Inc., has been picked as the best in its division of industry. In the materials handling equipment industry, Black, Sivalls & Bryson, Inc., won in the final considerations. Formal presentations of the awards will be made at the annual report awards banquet in the Grand Ballroom of Hotel Pennsylvania in New York on Friday, October 10. The publication, Financial World, sponsors the annual report survey.

Taylor Appoints New Executive

At a recent meeting of the board of directors of Taylor Instrument Companies, Herbert J. Noble, vice president and treasurer, was elected to the position of executive vice president and assistant general manager. He will retain his position as treasurer. Noble joined Taylor in 1907 as an accountant. In 1934 he was elected a director; in 1938 treasurer, and in 1946 vice president. He is chairman of the financial executives committee of the recorder-controller section of Scien-

tific Apparatus Makers of America, a former director of the Rochester section of Controllers Institute of America; and a member of National Association of Cost Accountants and Rochester Chamber of Commerce.

McKimmey Appointed Sales Manager

V. H. McKimmey has been appointed sales manager of Mechanical Manufacturing Co., Inc., Fort Worth. He recently has been purchasing agent of Rowan Drilling Co., Fort Worth, and formerly had been associated with National Supply Co. and other firms in Texas and Oklahoma in executive capacities.

Chase Brass Promotes Malvey

Edward J. Malvey has been promoted to the position of advertising manager of Chase Brass & Copper Co., Waterbury, Conn. Malvey, a native of New Haven, became associated with Chase in 1924 when he relinquished a position in the advertising department of Winchester Repeating Arms Co., New Haven, to accept a similar one under Rodney Chase, who was then advertising manager.

Lincoln Foundation Appoints Assistant Secretary

Dr. E. E. Dreese, chairman of the board of trustees of James F. Lincoln Arc Welding Foundation, Cleveland, announces the appointment of Charles G. Herbruck as assistant secretary of the foundation. Herbruck is a graduate of Princeton University and will bring to the foundation an experience drawn from a wide variety of sources including selling, newspaper work, and industrial management.

Steiner Succeeds McCool

Harry Y. McCool, Sr., superintendent of maintenance of Timken Roller Bearing Co.'s Steel and Tube Division, has retired after more than 30 years of service. Leland S. Steiner has been named as McCool's successor.

Hammel-Dahl Names Clark

O. T. Clark, Clark Sales Engineering Co., Decatur, Ga., has been appointed dealer representative in the Southeast territory for Hammel-Dahl Co., Providence, R. I.

New Patterson-Ballagh Office in Alice

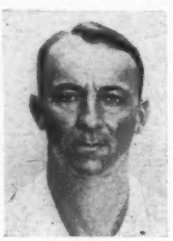
Removal of the Patterson-Ballagh office in Alice, Tex., to the Alice Specialty Warehouse on the Falfurrias Highway has been completed by "Bud" H. H. Collins, in charge of the office.

"Dick" W. W. Simpson has joined Patterson-Ballagh as city salesman in Houston. After several years of service in the Army, Simpson was employed by Lone Star Cement Co.

Reese Constructs New Plant

A new instrument manufacturing and repair plant is being constructed by W. M. Reese, owner of Industrial Instrument Co., Odessa. The new plant when completed with equipment will cost over $100,000. Reese represents many instrument manufacturing companies of this area and will carry a complete stock of their instruments and accessories.

Sutton to South America



Hammond Latino - Americana S.A., wholly owned subsidiary of Hammond Iron Works, Warren Pa., and Port Neches, Tex., recently organized to field erect storage tanks throughout South America, announces that Raymond Sutton, general superintendent, has left for Venezuela where he will superintend the construction of storage tanks to hold 3 million barrels of Venezuelan oil.

Personnel Changes In Link-Belt

Link-Belt Co., Chicago, announces the following changes in sales management personnel: James B. Elliott, heretofore divisional manager for Caldwell plant products, with headquarters at the Caldwell plant in Chicago, has been appointed divisional sales manager at the company's plant in Minneapolis. Erwin A. Wendell, heretofore district sales manager, Chicago branch, with headquarters at the Pershing Road plant, has been appointed divisional sales manager for Caldwell-plant products, with headquarters at the Caldwell plant. T. W. Matchett, heretofore district sales engineer at New York, has been appointed district sales manager, Chicago branch, with headquarters at the Pershing Road plant.

Autocar Establishes Texas Branches

Autocar Co., Ardmore, Pa., has announced establishment of a new branch in Dallas at 1505 Federal Street. M. K. Bailey is district manager. He previously had covered the Texas territory from headquarters in St. Louis. As a further step to increase its sales facilities in the oil country, the company is also building a branch in Odessa, Tex., where it expects to have a large service organization.

All American Industries Purchases A. D. Cook

All American Industries, Inc., announces acquisition of the entire outstanding capital stock of A. D. Cook, Inc., Lawrenceburg, Ind. A. D. Cook is a manufacturer of a diversified line of deep-well steam-driven pumps, plunger pumps, and turbine motor-driven pumps, shallow-well pumps, well supplies, and compression-type fire hydrants.

This is the third acquisition in allied fields by All American Industries during the current year, it having previously acquired Oklahoma Steel Castings Co., Tulsa, producers of steel castings, and the FitzSimons Steel Co. of Youngstown, Ohio, producers of cold-drawn steel bars.

In connection with the A. D. Cook acquisition, it was explained by Robert C. Hardy, president of All American Industries, that Cornelius O'Brien, who has been president of that company for a number of years, will continue in an active capacity with that company as chairman of the board, and that all other key personnel will be retained.

Appointments Announced By Raybestos-Manhattan

Raybestos-Manhattan, Inc., recently announced the following appointments in its equipment sales division: Harry C. Dishman, equipment sales manager with headquarters in Detroit; George T. Young, branch manager of the Detroit office; E. E. Juergens, branch manager of the Cleveland office: and John E. Cole, branch manager of the Chicago office.

Wert Heads New Division

Chicago Metal Hose Corp. has appointed Edwin A. Wert as director of sales for its expansion-joint division with offices in Maywood, Ill.